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NOISE AND NOISE ABATEMENT AS IT RELATES TO INDUSTRIAL EDUCATION WOODWORK SHOPS

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NOISE AND NOISE ABATEMENT AS IT RELATES TO INDUSTRIAL EDUCATION WOODWORK SHOPS

by

Keith L Evans

1983

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Chapter 1 - Introduction

Noise levels generated by machinery in high school woodwork shops are frequently high and a concern to both teachers and students. It has been well established that continuous exposure to noise of high levels can lead to permanent hearing loss or permanent threshold shift.[1,2] The following study attempts to address this concern by looking at major questions:

1. Do the noise levels generated by equipment in school woodwork shops exceed the permissible noise exposure criteria of the Workers' Compensation Board of British Columbia?

2. What methods of noise abatement are available and cost effective?

It may be suggested that ear plugs or ear muffs would provide a simple solution to high noise levels in shops and the hearing loss which might result. Although this may be a partial solution in some circumstances, it is not the best answer to the overall noise problem in the school shop, for the following reasons:

a. Ear muffs or ear plugs are uncomfortable and it is difficult to make students wear them for any length of time.

b. Ear muffs or plugs can cause or encourage ear infections, dermitius, or even lice.

c. Noisy machines disturb all the students in the shop, not just the operator.

d. Noise levels are sometimes high enough to disturb students in adjacent classrooms.

e. There are usually many activities in progress at one time in the shop and the high noise levels add an unnecessary stress to the learning environment.[3]

f. Although this study does not deal with physiological

effects or psychological effects besides noise-induced hearing loss, there is evidence regardless of ear protection that exposure tohigh levels of noise over long periods of time can be detrimental to health.[4,5] Students are not usually exposed to noise as long as teachers.

g. Workers' Compensation Board of British Columbia considers ear protection as an interim or last resort solution and has legislated engineering control methods in situations where noise levels are above the permissible limits.[6]

This study assumes that noise can be controlled at the source or in its path thereby removing the need for personal ear protection. The major part of this study will look at the nature of noise generation and methods of controlling woodwork machinery noise at the source.

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4. U.S. Department ofLabor,OSHA, Noise Control - A guide for workers and employers (Washington D.C.: 1980), p. 2.

5. Health and Welfare Canada, Noise and Hazard Control (Ottawa: publication #79-EHD-29, 1979), pp. 22-23.

6. Workers' Compensation Board of British Columbia, Industrial Health and Safety Regulations (B.C.: 1980), section 13.21.(1)

Chapter II - Terminology

The realm of sound and noise control engineering is so vast it would be impossible to discuss all aspects in a study of this kind. Therefore, this study examines noise control as it applies to woodwork machinery. A knowledge of the following terms will aid the reader in understanding the concepts presented:

1. Sound Pressure Level (SPL). Sound is defined as any air pressure variation the human ear can detect. The smallest sound pressure change the ear can perceive is a 20 millionth of a pascal or 20 micropascals(20 uPa.) Amazingly, the ear can tolerate sound pressures more than a million times greater. If we had to measure sound pressure levels in pascals we would end up with quite large and unmanageable numbers. To avoid this, a logarithmic scale has been devised which represents the complete range on a scale of 1 to over 150. This is termed the decibel scale.

2. Decibels. This scale is a convenient measure of sound pressure levels. A six decibel increase in the sound pressure is equal to a doubling of the sound pressure or conversely a six decibel decrease is a halving of the sound pressure. One decibel change in one part of the scale is the same relative change as one decibel change in another part of the scale. The symbol used for decibel is dB. See table 1 for a reference to where typical sound pressure levels are located.

3. Frequency. The human ear can perceive a frequency range of from 20 to 20 000 cycles per second. The unit of frequency is

the hertz(Hz). Normal conversation is mainly in the 500 Hz to 3 000 Hz range.

Table 1 - Decibel Scale

	140 dB	jet engine (25 m)
100 000 000 uPa		
	130 dB	jet taking off(100 m) threshold of pain
	120 dB	chain saw
10 000 000 uPa		
	100 dB	full symphony orchestra at full volume
1 000 000 uPa		
	80 dB	average street traffic
100 000 uPa		
	60 dB	normal conversation
10 000 uPa		
	40 dB	average living room
1 000 uPa		
	20 dB	whisper
100 uPa		
20 uPa	0 dB	threshold of hearing

4. Octave Bands of Frequencies. In order to represent properly a noise source, it is desirable to break the total noise into its various frequency components. This is essential for any comprehensive study of noise problems since engineering solutions to reduce or control noise are different for noises of different frequencies. Table 2 represents the nine octave range with their geometric means.

5. "A"-Weighted Scale. The A-weighted sound pressure level,

abbreviated by the letters dB(A), represents a single number indicator of the relative loudness of a sound as heard by the human ear. The human ear is more sensitive to higher frequency than it is to lower frequency sounds. Two sounds, equal in magnitude but different in frequency will not be judged equally "loud" by the ear. Therefore, sound pressure meters have an "A Scale" which weights the sound pressure level to a relative loudness as heard by the human ear.

Table 2 - Octave Bands

Octave Frequency Range - Hz	Mean Frequency of Octave Band - Hz
22 - 44	31.5
44 - 88	63
88 - 175	125
175 - 350	250
350 - 700	500
700 - 1400	1000
1400 - 2800	2000
2800 - 5600	4000
5600 - 11200	8000

6. Loudness. When a sound is increased by about 10 dB in level, people typically judge it to be about twice as loud as before. It should be noted that a 6 decibel increase is a doubling of the sound pressure but it takes 10 decibels for our ears to perceive a doubling. We can normally perceive a difference of 2 to 3 dB.

7. Sound Pressure Level Verses Distance. In an outdoor situation with no reflective surfaces except the ground, the sound pressure level decreases at the rate of 6 dB for each doubling of the distance from the acoustic center of the source.

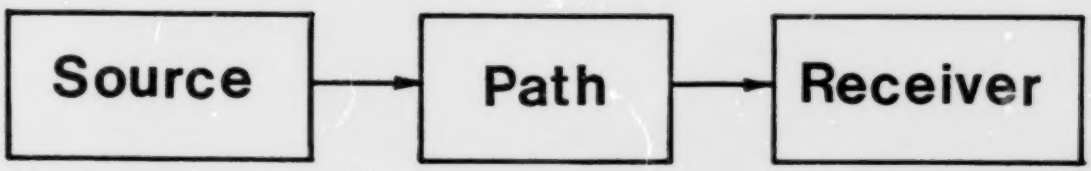
In an indoor situation, the sound waves bounce around within the room because sound energy is trapped. Although a certain amount of energy is absorbed at each reflection, there is a build-up of the sound level. In a highly reverberent room with walls that are hard and rigid very little sound energy is absorbed. In such a room the sound pressure level drops off very slowly, possibly only 1 to 2 dB per doubling of the distance. Only if the walls absorb 100% of the sound energy would the situation be the same as that for outdoor free-field conditions.

The reduction of sound pressure level indoors, as one moves across the room away from the sound source, is therefore dependent on both the degree of absorption and the distance that one moves.

8. Equivalent Energy Level (Leq). The hearing damage potential of a given noise depends not only on its level, but also its duration. For example, a one minute exposure to a noise is not as harmful as a 60 minute exposure to a noise of the same level. Thus, to assess hearing damage potential of a noise, both its level and duration must be measured. For constant levels this is easy, but if the level varies, the level must be sampled repeatedly over a well definded sampling period. Based on the levels sampled, it is possible to calculate a single energy level, called Leq, which represents an equivalent continuous level in

dB(A) which has the same hearing damage potential as the varying level. Noise dose meters or dosimeters perform the calculations automatically.

9. Basic Noise Control System. An understanding of the basic noise control system is necessary in dealing with noise problems. This system consists of a source, a path, and a receiver. The source is often the machine itself, the path is usually the air, and the receiver is the machine operator. The source is usually a vibrating surface or turbulent air flow producing pressure fluctuations that travel through the air and reach the receiver's ears. Noise control usually takes the form of design changes at the source, acoustic enclosures or barriers in the path, and ear protection at the receiver.



Chapter III - Noise In School Woodwork Shops

A study was conducted in nine junior high and three senior high school woodwork shops in School District 43 (Coquitlam) in order to establish the sound pressure levels for different shop machines and to determine if those levels exceeded Workers' Compensation Board of British Columbia regulations. The equipment and tools in the schools are representative of the equipment in most woodwork shops in the province. Each shop was visited and sound level measurements were taken as the students carried out their normal activities. A dosimeter reading of shop noise and an octave band analysis of selected machines were also taken. Measurements were taken only of machines that generated a high level of noise.

A. Woodwork Machinery Noise

1. Measuring Equipment and Procedure. A Quest #215 Sound Level Meter and a Quest #215-45 Octave Band Analyzer (figure 1) were used to measure the noise level. The meter was tripod mounted and the measurements were taken near ear level height to the side of the operator. Care was taken not to hold the meter between the noise source and the operator or observer because sound reflections from the body could distort the readings. A minimum of three readings was taken for each situation and an average reading recorded. Frequently all readings taken were identical or varied only one decibel. Although the meter was on the slow needle setting, sometimes the needle would fluctuate

one or two decibels while taking a reading. In those cases the highest position the needle reached was used. The meter calibration and batteries were checked before each recording session.

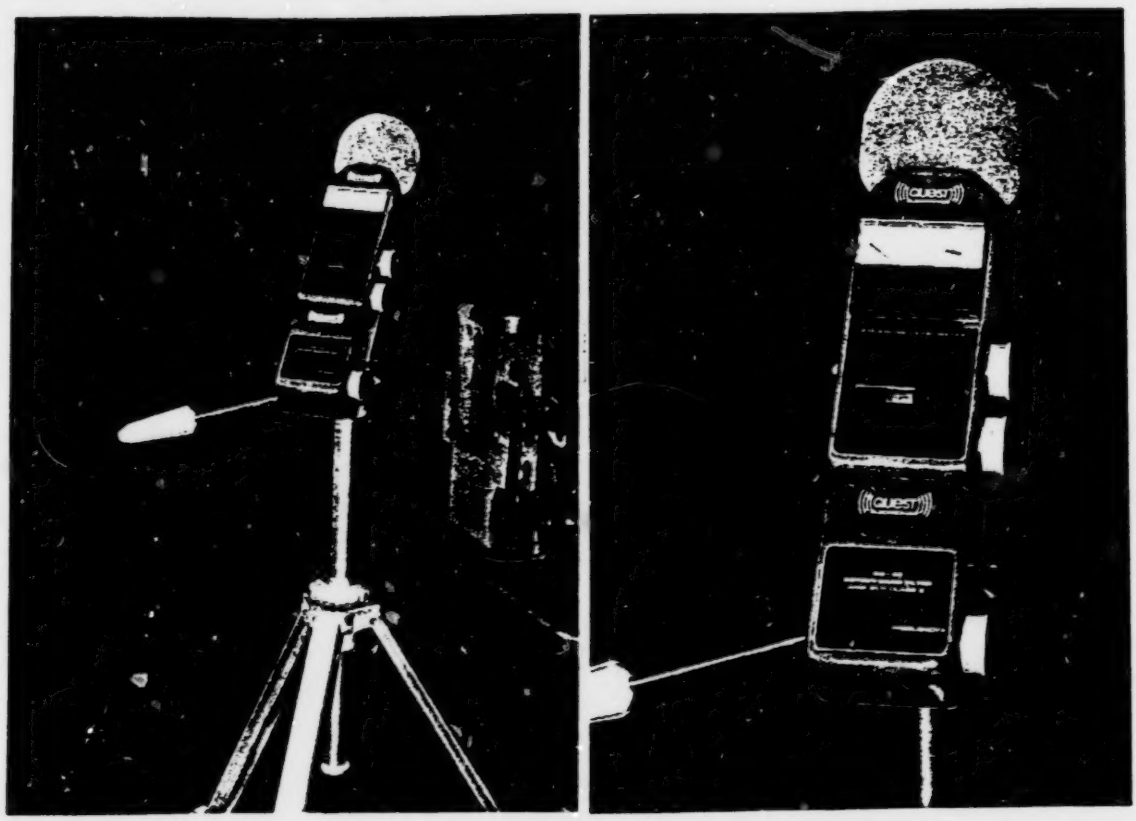


Figure 1 - SPL Meter and Octave Band Analyzer

An octave band analyses was taken for the thickness planer, jointer, table saw, and radial arm saw in each shop. So readings would be comparable, the meter was positioned the same in relation to the machines at the different schools. All readings were taken with the exhaust system turned on since it was the normal operating situation and usually had little or no effect on meter readings. Octave band readings were taken with little or no other activities taking place so background noise would not be a confounding influence. It was very awkward and time-consuming to take octave band analyses with the metering equipment while the machines were cutting wood. Therefore, all octave band readings were taken with the machines idling and dB(A) readings only while the machines were cutting wood.

2. Noise Levels of Machinery. The position of a machine in the shop, the sharpness of the knives, the density of the sample piece of wood, the rate of feed, the thickness of cut are some of the variables encountered in the source of noise in the woodwork shop. It was not possible to control all the variables to get an exact comparison between machines in the sample shops. Later in the study where specific treatments were tried these variables were controlled. However, the purpose of this part of the study was to establish general noise levels for the different machines and to determine if there are reasons for concern. An average of twenty-five noise level readings were taken in each machine catagory from the twelve shops. Table 3 shows a range of the readings recorded with an average calculated to give a

Table 3 - Machinery Noise Level

Machine	Idle Noise Levels		Cutting Noise Levels	
	Range dB(A)	Average dB(A)	Range dB(A)	Average dB(A)
Thickness Planers				
14" General (3 machines)	77-82	80	100-110	106
18" Powermatic (2 machines)	84-89	87	106-115	112
18" Powermatic Quiet-One (3 machines)	76-82	79	90-109	100
24" Invincible & Wadkin (3 machines)	95-98	96	102-116	109
Radial Arm Saws				
10" Rockwell & DeWait (3)	86-92	89	98-110	105
12" Rockwell & DeWalt (6)	90-97	91	98-112	105
14" Wadkin (2 machines)	95-97	96	97-104	100
Jointers				
6" Rockwell & General (4)	78-82	80	84-96	88
9" Wadkin (6 machines)	80-97	88	86-104	96
12" Invincible (1 machine)		91	98-110	104
Table Saws				
10" Rockwell & Wadkin (12 machines)	76-90	86	86-100	94
Hand Electric Routers				
Rockwell, Craftsman, Makita Stanley, Black & Decker (10 machines)	93-97	95	89-108	99
Hand Electric Belt Sanders				
Rockwell, Skil, Milwaukee (5 machines)	94-102	98	94-102	98
Hand Electric Circular Saws				
Black & Decker, Skil, Milwaukee (4 machines)	96-102	99	96-102	99
Vibrator Sanders				
Rockwell, Makita, Milwaukee Black & Decker (8 machines)	79-96	90	79-96	90
Motorized Mitre Box				
Makita (2 machines)	98-102	100	102-106	104

representative noise level reading.[1]

According to the chart from the Workers' Compensation Board of B.C. (table 4) there is potential cause for concern depending on the length of exposure time if a machine records over 90 dB(A) noise level. Ear protection must be used when noise levels exceed 105 dB(A). An examination of table 3 shows thickness planers and radial arm saws were frequently in the 105 dB(A) or higher level when cutting. Therefore, ear protection would be highly advisable when using the thickness planer.

Table 4 - Steady State Noise

Noise Level - dB(A)	Maximum Daily Exposure Time Without Hearing Protection - hours
87	16
90	8
93	4
96	2
99	1
102	0.5
105	0.25
over 105	0

Other shop machines frequently approach this level. It must be remenbered in a school woodwork shop of twenty or more students many of the machines may be operating simultaneously. The average shop is approximately 30' x 70' x 12' high with walls, floor, and ceiling of hard surfaces which are good reflectors of sound. The shop acts as a reverberation chamber making it a very irritating

place to work. The effects of wall and ceiling surfaces were not investigated in this study.

In an industrial setting noise generated by machinery tend to be steadier and the need for hearing protection is more obvious. However, in a school setting the use of machines are more intermittent; lectures, demonstrations, period changes tend to reduce the on time of machines. Although this may reduce the accumulated noise exposure per day, the many times the noise approaches potential hearing lose levels may not be obvious. However, this study does establish that the noise levels generated by machines in school woodwork shops pose a potential danger to hearing of which people should be aware.

B. Noise Exposure Comparison

Several teachers in Coquitlam have expressed concern about the potential damage to their hearing from high levels of noise in the woodwork shop. Recall the two major causes of hearing loss are high levels and the duration of the noise. This part of the study will deal with the duration of the noise.

1. Measurement Equipment and Procedure. A Quest #M-8 Dosimeter, see figure 2, was used to measure exposure to noise accumulated over the working day. The batteries and calibration of the dosimeter were checked before each recording period. The dosimeter microphone was fixed to a shop worker's collar to keep it near ear level so as to give a sound pressure level reading similar to that which the ear would experience. To start a recording period the dosimeter was positioned to zero and the

time recorded. The person wearing the meter, usually the teacher, went about his work in the normal way. The dosimeter accumulatively records all sound pressure levels to which the wearer is exposed. A protective cover was placed over the dosimeter to prevent accidental disturbance of the controls. After a period of work time the dosimeter was shut off and the time and percentage readings recorded. The percentage value was converted to an eight hour equivalent dB(A) or Leq value. A reading of 100% is equivalent to 90 dB(A) for eight hours. Also, the dosimeter indicates noise levels that exceed 120 dB(A). Noise over 120 dB(A) is approaching the threshold of pain level and is considered a serious noise problem requiring immediate attention.

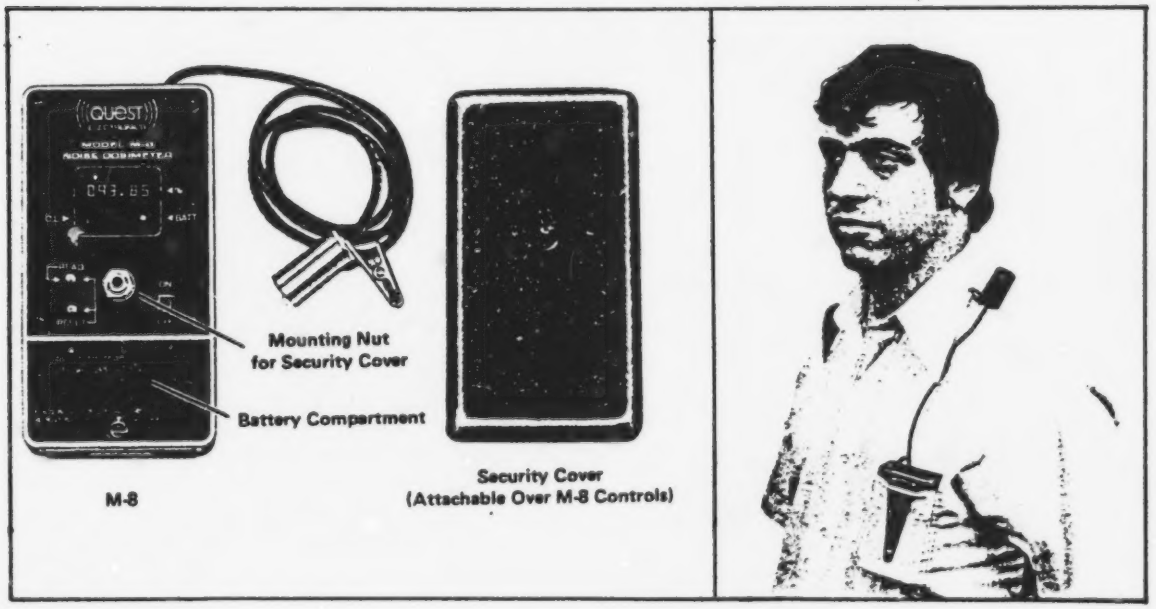


Figure 2 - Dosimeter

Table 5 shows the readings obtained from varying times measured at the different schools. The junior and senior high schools were separated in the chart. The difference of almost 5 dB(A) between the junior and senior shops bears out the fact senior shops make greater use of power tools. One junior shop had a high 8 hour equivalent of 91.5 dB(A). This is likely because that shop had a noisy thickness planer which was being used extensively during the time the readings were taken. The column in table 5, labelled "Allowable Exposure Time/Day," gives a projected length of time per 24 hour day a person could be exposed to the levels of noise measured in the shops without the use of hearing protection (according to Workers' Compensation Board criteria).

2. Analysis of Results. In the twelve schools measured, the dosimeter did not indicate any noise over the 120 dB(A) level, indicating no serious noise problem requiring immediate consideration.

The Leq measurements taken in the junior high woodwork shops generally are below levels which would cause concern. However, in the senior high woodwork shops the allowable exposure time per day is very close to the time the shop is in operation. On any given day with extensive use of the thickness planer and/or radial arm saw, the Leq value could easily exceed acceptable limits.

The question of whether the noise levels in school woodwork shops exceed the permissible exposure regulations of the Workers'

Table 5 - Leq Values For School Shops

		Dosimeter Readings - %	Time Exposed - hours - minutes	Equivalent Sound Level-Leq - dB(A)	Allowable Exposure Time/Day - hours (W.C.B. criteria)
	1	5.68	1 hr. - 39 min.	84.5	24
	2	9.26	0 hr. - 57 min.	89	10
	3	40.73	3 hr. - 6 min.	90	8
Junior	4	15.67	3 hr. - 0 min.	86.25	19
High	5	54.39	3 hr. - 11 min.	91.5	5.75
Schools	6	8.76	1 hr. - 54 min.	85.5	21
	7	10.62	3 hr. - 22 min.	84	24
	8	21.34	3 hr. - 0 min.	87.5	14
	9	19.29	3 hr. - 19 min.	87	16
			AVERAGE	87.25	15
Senior	10	33.10	2 hr. - 10 min.	91	6.5
High	11	45.12	1 hr. - 55 min.	92.25	4.25
Schools	12	56.29	2 hr. - 34 min.	92.5	4.5
			AVERAGE	92	5

Compensation Board of British Columbia is very difficult to establish firmly. The difficulty partially arises from the day to day variability in shop activities. However, the results obtained for this study indicate that although there are offending noise levels in secondary school woodwork shops, the levels do not occur for sufficient duration to exceed Workers' Compensation Board regulations.

Another issue which has been debated is whether the Workers' Compensation Board criteria of 90 dB(A) for 8 hour exposure is low enough to afford safe protection. Many have felt an 85 dB(A) for 8 hour exposure would be a much safer

criterion giving protection to a larger percentage of the population. In 1974 the Environmental Protection Agency(EPA) in the United States requested the Occupational Safety and Health Administration(OSHA) review its noise exposure regulations because it felt it "did not protect the public health and welfare to the extent required and feasible."[2] This study does not have time to explore this debate but with high school woodwork shops being close to the allowable noise exposure limit, teachers must be concerned with the possibility of the noise levels causing damage to hearing.

The dosimeter readings were taken for short periods of time at each of the schools. Although the results can be signposts they cannot be taken as conclusive evidence that noise in school woodwork shops cause hearing damage. A study conducted over a longer period and at peak machine use times during the year in many schools would be needed to firmly establish the safety of noise levels in the woodwork shop.

References -

1. David L. Chung, Wayne Everett, and Patrick Gannon, "Effects of Shop Noise on the Hearing of High School Children," prepared for the Vancouver School Board in cooperation with the Workers' Compensation Board of British Columbia,1978.

2. Daniel P. Boyd,"Occupational Noise Expo", Noise-Con 75, National Bureau of Standards (Washington D.C.,1975), p.151.

Chapter IV - Thickness Planer Noise Control

The thickness planer is the noisiest machine in the secondary school woodwork shop. The noise levels generated range from about 100 dB(A) to 116 dB(A) (table 3, page 11). Therefore, considerable effort was directed to noise abatement of thickness planers.

A. The Nature of Thickness Planer Noise Generation. The dominant sources of thickness planer noise appears to be of two types:

- aerodynamic noise when idling.
- vibrational noise during cutting.

The rotation of the cutterhead in close proximity to stationary surfaces, the pressure bar and chip breaker bar, creates aerodynamic noise. (figure 3) This the typical siren noise usually associated with thickness planers. When the knives strike the wood during cutting, vibrations are set up in the machine which are imparted to the wood being cut.[1]

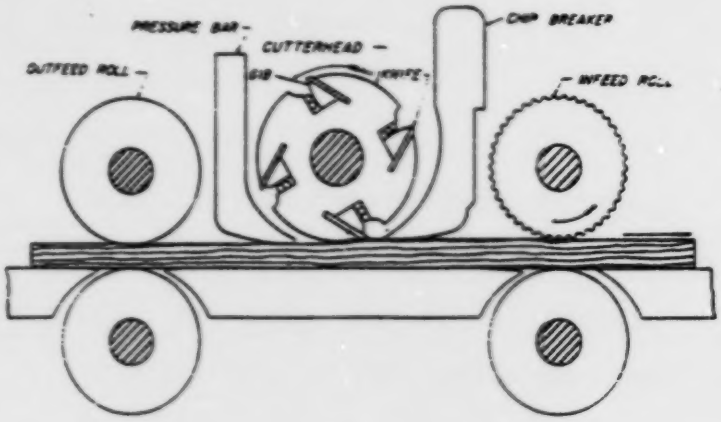


Figure 3 - Typical Thickness Planer Crossection

A poorly maintained machine can be a source of excessive noise. The condition of the bearings, lubrication of moving parts, belt alignment and tension can add to the overall noise level, although they are not usually a major source of noise. For example, bearings that need replacing can often cause an irritating rumbling noise that adds to the noise level of the machine. Electric motors usually add little to the noise level unless bearings are defective. The sharpness of the knives can be a very large factor in noise generation. Dull knives increase the striking force necessary and increase the vibration and sound energy level imparted to the wood being cut.

Another source of noise in thickness planers is the flow of air past the knives from the exhaust or chip removal system. However, the sound pressure level meter indicates an increase of zero to two decibels between the exhaust system off and the exhaust system on. This seems hard to believe since several teachers have complained about the noise from the exhaust system. Thus, the complaint must be the irritating frequency rather then sound pressure level. On the basis of results from this study, the system cannot be considered a major source of noise in most school shops.

The vibrations caused by cutting and the air flow could cause reverberation in the sheet metal pipes of the exhaust system. This problem is not large and is easily controlled through dampening materials.

B. Methods of Thickness Planer Noise Abatement. The following methods of thickness planer noise control were tried:

1. Improved knife maintenance
2. Reduced cutterhead r.p.m.
3. Segmented knives
4. Dampening material
5. Planer enclosure
6. Cutterhead design

To control the variables in the testing the following steps were taken. First, a piece of 2" x 8" American red oak was used as a standard test piece. Second, a 1/16" thick cut was the amount removed on each test cut. Third, the same piece of wood was used before and after a modification to the thickness planer. Fourth, the sound pressure meter was positioned at the same location on each test. Fifth, the battery level and the calibration of the meter was checked before each test. Sixth, the exhaust system was on and the other activities in the shop stopped.

The results which follow ranged from little effect to extensive abatement of noise.

1. Improved Knife Maintenance. The sharpness of the planer knives has a large effect on the noise generated while cutting. Readings were taken on two thickness planers with dull knives cutting a test piece of wood. The knives were sharpened and the test piece of wood was cut. Table 6 shows the significance of the sharp knives. A 10 to 14 decibel drop in noise levels was

obtained. Considering a drop of six decibels is a halving of the sound pressure level, the comparison indicates that the maintenance of knife sharpness is a worthwhile means of noise abatement. Thickness planers with built in sharpening devices provide a quick and easy method of maintaining blade sharpness.

Table 6 - Sharp Verses Dull Knives

Planer	Dull Knives - dB(A)	Sharp Knives - dB(A)	% Sound Pressure Level Decrease
14" General	103 - 105	94 - 95	90%
24" Invincible	114 - 116	100 - 102	94%

2. Reduced Cutterhead R.P.M. Scientifically, the noise generated by a planer is proportional to the fourth power of the cutterhead's knife tip velocity.[2] Reducing the speed of the cutterhead proved to be very effective in noise reduction.

The sound level readings of several 14" General thickness planers demonstrated a large difference in noise levels. Further investigation indicated that the speed of the cutterhead of the quietest planer was 4100 r.p.m. The speed of the cutterhead of the noisiest machine was 8200 r.p.m. due to an error in matching motor speed and pulley ratios. A new belt and pulley were installed reducing the speed to 3550 r.p.m. resulting in a drop of 17 dB(A) in idle noise and a drop of 5 dB(A) when cutting, see table 7. The knives were slightly dull and unchanged both before and after the speed reduction. The knives were sharpened

Table 7 - Effects of R.P.M. on Noise Generation - General Planer

Octave Band Frequency Analysis

MACHINE - 14" General Planer

TEST EQUIPMENT - QUEST #215-45 S.P.L. METER AND OCTAVE BAND ANALYZER

TEST #1 - 4100 r.p.m., idle noise, exhaust on, meter position in front of machine at ear level.

TEST #2 - same as test #1 but 8200 r.p.m.

TEST #3 - same as test #1 but 3550 r.p.m.

TEST	#1	#2	#3
dB(A)	82	99	82
dB LIN.	88	102	84
31 Hz.	64	72	62
63 Hz.	84	66	68
125 Hz.	74	75	76
250 Hz.	81	90	78
500 Hz.	84	101	82
1K Hz.	79	96	79
2K Hz.	70	86	73
4K Hz.	66	77	63
8K Hz.	64	67	51

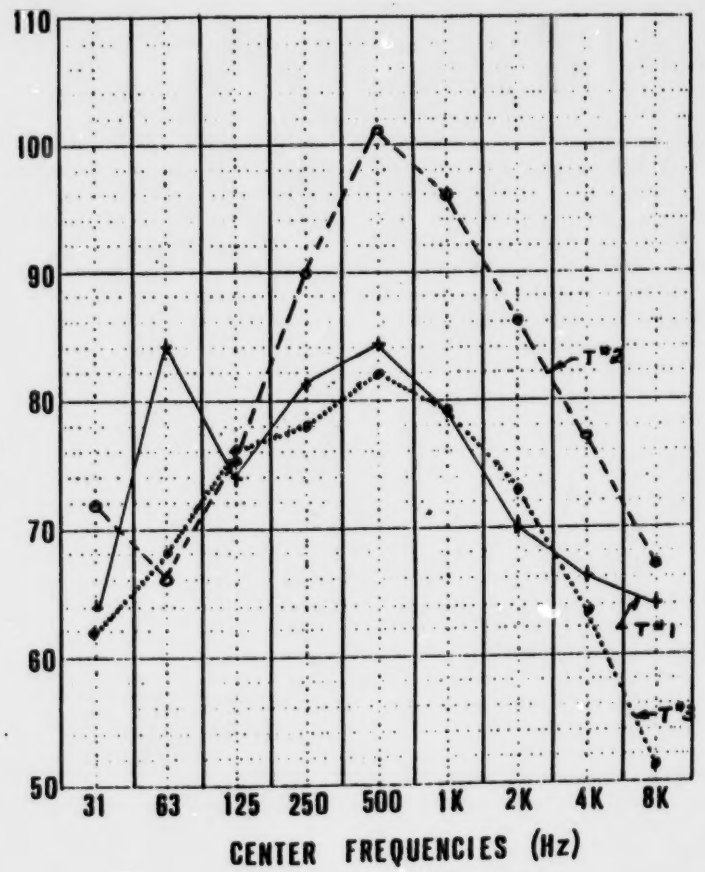


Table 8 - Effect of R.P.M. on Noise Generation - Invincible Planer

OCTAVE BAND FREQUENCY ANALYSIS

MACHINE - 24" Invincible Planer

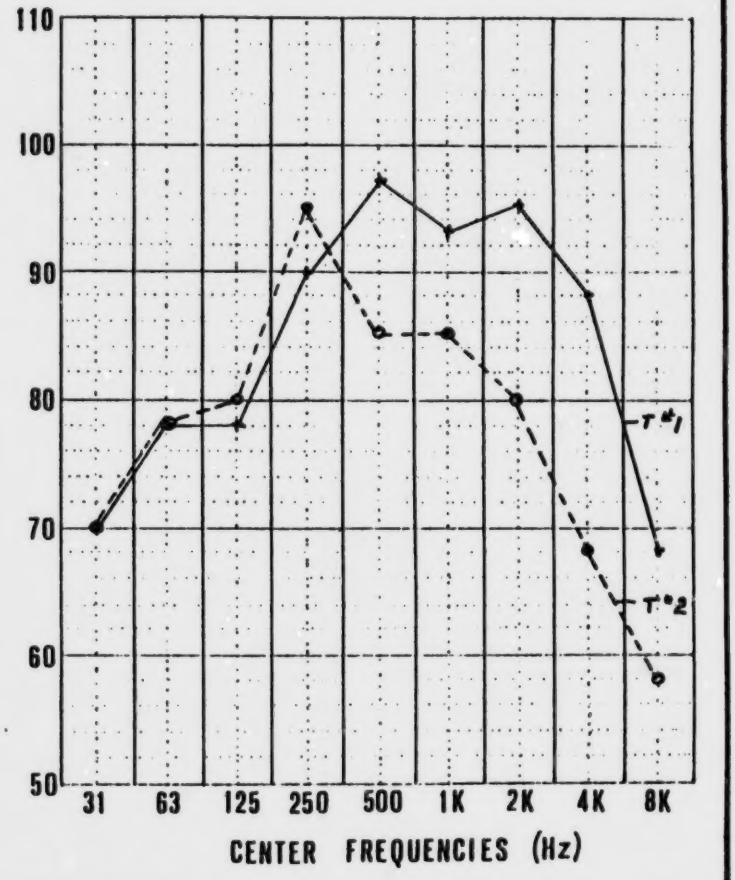
TEST EQUIPMENT - QUEST #215-45 S.P.L. METER AND OCTAVE BAND ANALYZER

TEST #1 - 5600 r.p.m., idle noise, exhaust on, meter position in front of machine at ear level.

TEST #2 - Same as test #1 but 3850 r.p.m.

TEST #3 -

TEST	#1	#2	#3
dB(A)	98	90	
dB LIN.	100	96	
31 Hz.	70	70	
63 Hz.	78	78	
125 Hz.	78	80	
250 Hz.	90	95	
500 Hz.	97	85	
1K Hz.	93	85	
2K Hz.	95	80	
4K Hz.	88	68	
8K Hz.	68	58	



and the noise level was reduced a further 10 decibels.

Similar results were obtained with the Invicible thickness planer when the speed of the cutterhead was reduced to 3850 r.p.m. from 5600 r.p.m., table 8. The change in the cutterhead speed had no noticeable effect in the quality of the surface finish of the wood on the slower feeds. On fast feeds there will be more knife ripple marks, but as school shops are not production shops where time is significant, fast feed is not important.

3. Segmented Knives. The shops under study had two 18" Powermatic regular thickness planers and three 18" Powermatic Quiet-One thickness planers providing a good opportunity for comparison. The basic difference between the two machines is the Quiet-One has a nine slot cutterhead with three - 3" knives per slot (27 knives) compared to the regular machine which has three slots with three full length knives, figure 4.

Figure 4 - Powermatic Quiet-One Segmented Knives

The regular 18" Powermatic cutterhead turns at 4600 r.p.m. while the Quiet-One turns at 3300 r.p.m., see table 9.

The disadvantage of a greater time and effort to sharpen or change the knives of the Quiet-One is definitely offset by the marked reduction in idle and cutting noise.

Table 9 - Comparison of Powermatic Thickness Planers

18" Powermatic Thickness Planer	School	R.P.M.	Idle Noise Level-dB(A)	Average dB(A)	Cutting Noise Level-dB(A)	Average dB(A)
Regular	1	4700	89	86.5	106 - 110	108
	2	4600	84		106 - 110	
Quiet-One	3	3600	80	79.3	98 - 102	100
	4	3250	76		96 - 98	
	5	3300	82		100 - 104	
Difference				7.2		8

The cutting noise of regular Powermatic thickness planers can be reduced by retrofitting the planer with a Quiet-One cutterhead. This is relatively easily done with a retrofit kit costing approximately $3500. The retrofit kit includes a nine slot cutterhead and 27 knives, an indexing plate for sharpening, a silencing package for the exhaust hood, and a vinyl-lead curtain for the entrance and exit holes on the planer.

In a 1978 study, Ehlert and Cunico reduced the aerodynamic noise generation of planers by grinding out sections of the knives.[3] Their study reported significant noise reduction of about 15 dB(A).

Ehlert and Cunico's study was partially replicated by grinding a set of four 24" planer knives for an Invincible thickness planer. Sections approximately 3" long by ½" deep were ground out of the knives in a staggered configuration so that at any one spot two of the four knives would be cutting.(figure 5) This modification should have lowered the aerodynamic noise generation by chopping up the air flow which creates the siren effect.

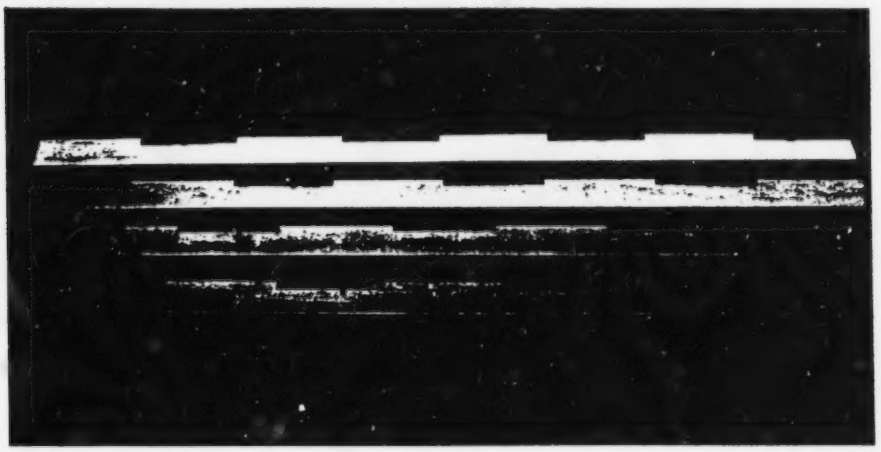


Figure 5 - Planer Knives - Stagger Ground Configuration

Table 10 compares the results of the Ehlert and Cunico study with the replication carried out in this study. The replicated study showed a reduction of only 3 dB(A) in both the idle and cutting mode. This disagreed significantly with Ehlert and Cunico. If Ehlert and Cunico's knives were dull before the modification was made and then sharpened before being put back in the machine, this might account for such a big difference. Modifying the knives similar to Ehlert and Cunico's method results in a need

to exercise increased care in mounting the knives in the cutterhead so all the knives are the same height. Different height knives will leave lines in the wood being planed. The effort and cost required to grind the knives did not result in a large enough reduction in noise generation. The cost of a set of Invincible planer knives is about $200. On the basis of the results obtained in this study, the modification of knives is not recommended.

Table 10 - Comparison of Studies

	Ehlert and Cunico Study (cutting 2" x 8" oak)	Evans Study (cutting 2"x8" oak)
Before stagger ground	122 dB(A)	101 - 102 dB(A)
After stagger ground	96 dB(A)	97 - 98 dB(A)
Difference	26 dB(A)	3 - 4 dB(A)

4. Dampening Material. Another approach suggested by the Ehlert and Cunico study was to undercoat all inner surfaces near the cutterhead with an automotive tar based undercoating material. In theory, the undercoating material absorbs some of the sound energy and converts it to heat energy. The undercoating material first tried in this study was a tar emulsion typical of this type of coating. It was found to be unsatisfactory because it took too long to cure and never completely dried. Another dampening material, Aquaplas DL, was tried. This product, although messy to apply, dried to a hard porous surface. The Aquaplas DL was

applied to the 24" Invincible thickness planer on the underside of the heavy cast iron top cover. It was applied about ¼" thick over the inner surface using about 2½ gallons. Sound pressure level readings running the same piece of wood at the same thickness of cut were taken before and after the coating. A reduction of 3 to 4 dB(A) was achieved for both idle and cutting noise. Aquaplas DL costs about $60 for a 2½ gallon pail. It would appear to be a reasonable method of noise abatement; although not large, it was effective for its low cost and ease of application.

Table 11 - Use of Aquaplas DL Dampening Material

	Idle Noise	Cutting Noise
Before Dampening Material Applied	92 dB(A)	98 dB(A)
After Dampening Material Applied	88 dB(A)	94 - 95 dB(A)

5. Planer Enclosure. Some research has been done on the use of an enclosure around planers in industrial settings.[4,5] Enclosures are usually about room size and are not really satisfactory for the school shop situation. The planers are frequently power fed automatically and continuously run with similar size material for several hours. For the school setting where many different sizes and types of wood are planed, the suggested enclosures are impracticable.

The best solution for the school woodwork shop is to enclose

the planer in a separate room isolated from the general shop area. This would eliminate the disturbing effect on the rest of the class. However, this is frequently not practicable in existing shops and the addition of a new separate room would be costly. In any new construction such a room should be given serious consideration. In fact, the British Columbia Department of Education has recommended this approach in any new construction of woodwork shops in the province. The separate room approach does not help the operator of the thickness planer, although, he would wear ear protection and would be exposed for only short periods of time. One difficulty of a separate planer room is the problem of teacher supervision; the student may not be visible. A planer room with large double glazed glass windows would help the supervision problem.

An experimental small box enclosure was built to cover the large 24" Invincible planer. The planer enclosure was patterned after the one built for the Burnaby School Board by Drexel Western Ltd. in 1976. The box was to meet five criteria. It was:

a. to be inexpensive and easily built from available materials.

b. not to inhibit operation of the machine.

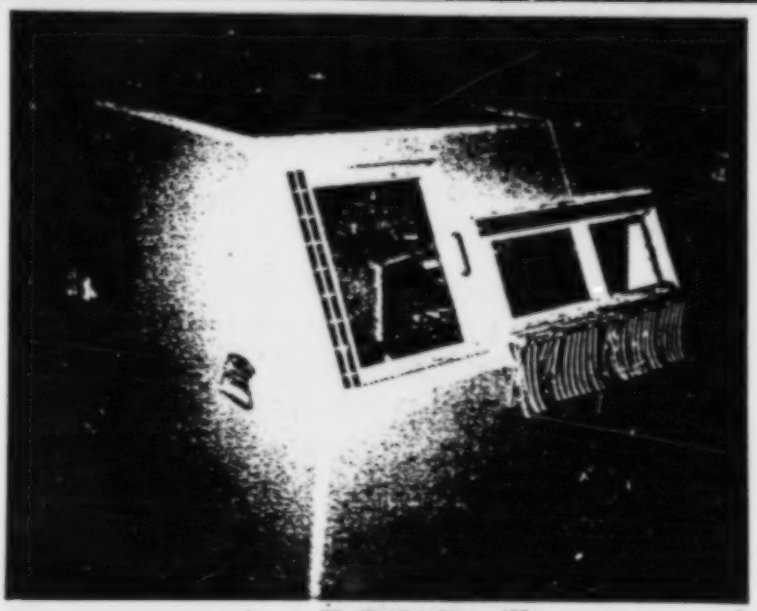
c. not to impair visibility of machine operation.

d. to allow easy access to controls.

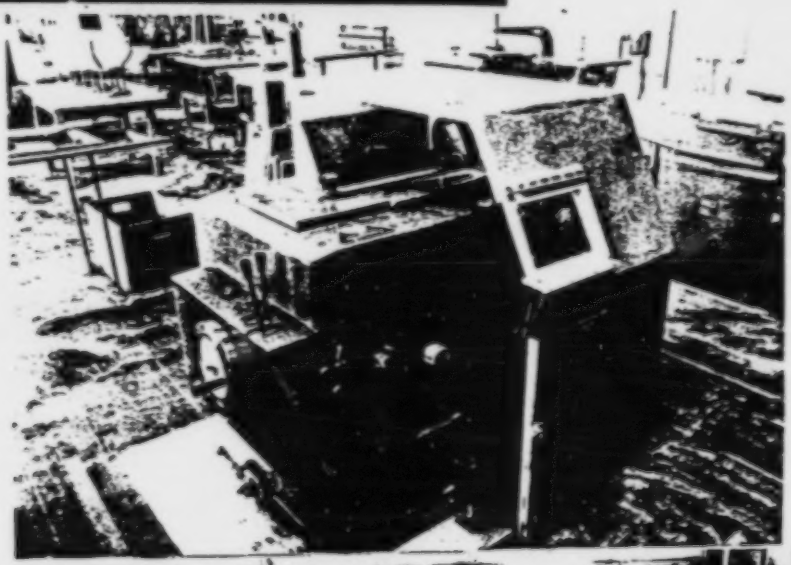
e. to be easily removed for maintenance.

Figure 6,7 and 8 describes the split box to house the 24" Invincible thickness planer and to satisfy the above criteria.

The noise reduction as shown by table 13 was a significant 8 dB(A) or well over half the sound pressure level present without



THICKNESS PLANER ENCLOSURE



The enclosure is easily removed for maintenance and knife sharpening.

FIGURE - 6

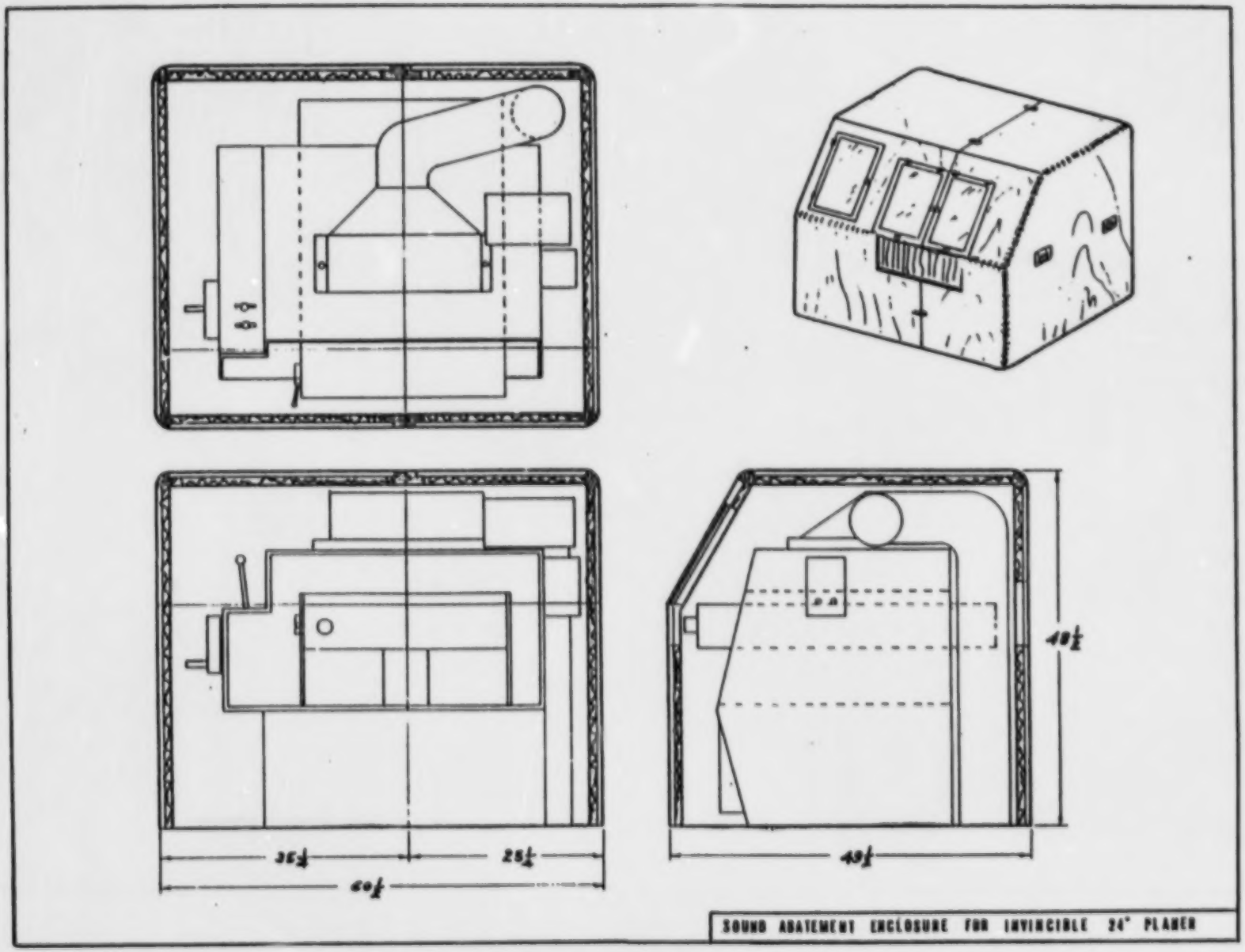
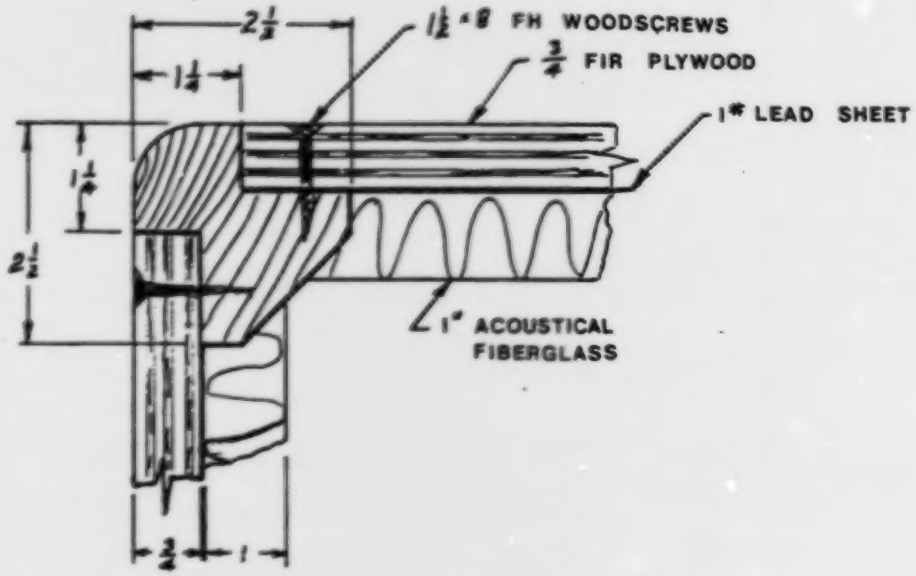
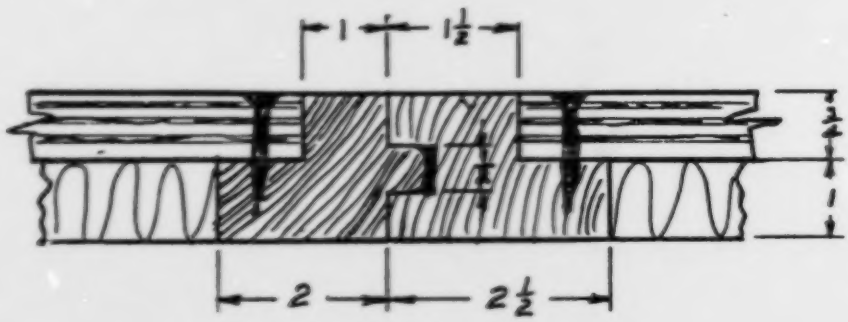


Figure 7 - Invincible 24" Planer Enclosure



SECTION OF CORNER



SECTION OF ENCLOSURE JOINT

PLANER ENCLOSURE	DRAWN BY – K L EVANS

Figure 8 - Planer Enclosure Details

Table 13 - Comparison of Noise Levels With and Without Enclosure

Octave Band Frequency Analysis

MACHINE - 24" Invincible Planer

TEST EQUIPMENT - QUEST #215-45 S.P.L. METER AND OCTAVE BAND ANALYZER

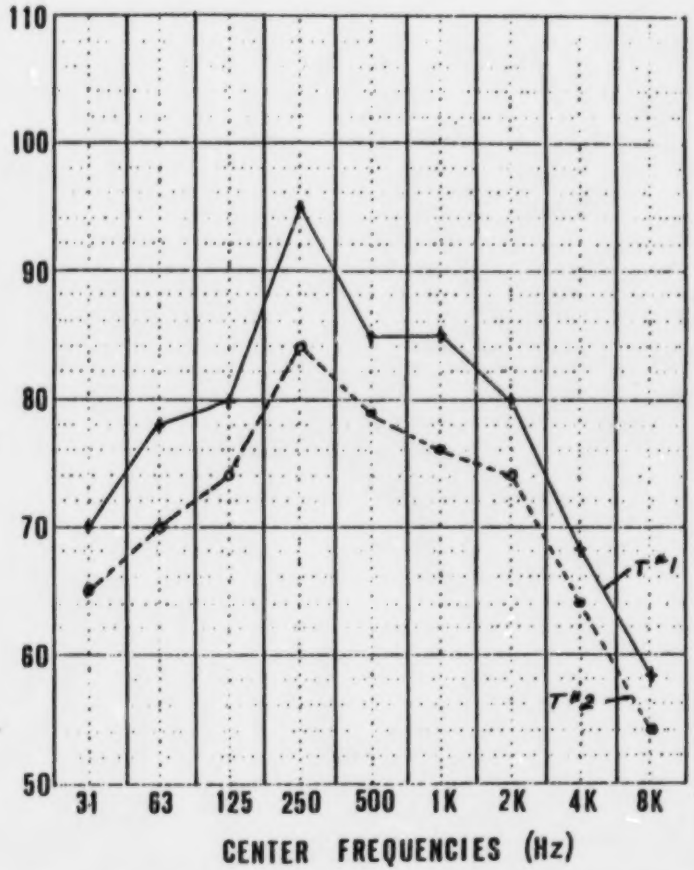
TEST #1 - Planer without enclosure - 3850 r.p.m., idle noise, exhaust on, meter position in front of machine at ear level.

TEST #2 - same as test #1 but with enclosure.

TEST #3 -

dB(A)

TEST	#1	#2	#3
dB(A)	90	82	
dB LIN.	96	84	
31 Hz.	70	65	
63 Hz.	78	70	
125 Hz.	80	74	
250 Hz.	95	84	
500 Hz.	85	79	
1K Hz.	85	76	
2K Hz.	80	74	
4K Hz.	68	64	
8K Hz.	58	54	



the enclosure.

The enclosure has been well received by the teacher and students using it. There have been few complaints. The reduction in noise far offsets the slight inconvenience of having to open the door to use the controls and the reduced visibility caused by the enclosure. Some difficulty with the vinyl-lead curtain on the input opening was experienced when starting a piece of wood into the machine. Modification may be required.

A compromise on the input and output openings was required. The longer the tunnel with the vinyl-lead curtain the better the noise reduction. However, the longer the tunnel the more awkward the enclosure is to use. The vinyl-lead curtain is desirable since it reduces the noise level by about 3 dB(A). Three curtains spaced 1" apart seemed to be a reasonable compromise.

The openings in the enclosure limit the size of lumber that can be planed to 4" thick which is adequate for most normal school shop needs. This reduces the size of the openings for noise radiation. If larger thicknesses of lumber need to be planed, the enclosure can quickly be pulled apart by releasing the four latches and pulling on the side handles.(figure 6) The plywood spacers around the base of the machine allow for alignment when reassembling.

Consideration was given to a means of supplying make up air to offset the air removed by the shaving exhaust system. However, this is not a problem since enough air leaks by the vinyl-lead curtain. Another improvement to the enclosure would be a light inside to help a person see the controls.

6. Spiral Cutterheads. A large portion of the noise of a thickness planer is generated when the knives strike the wood. The dominant frequency is the knife passage frequency; that is, the number of times a knife strikes the wood per second.

$$\text{Knife passage frequency (for Invincible planer)} = \frac{\text{number of knives} \times \text{r.p.m.}}{60}$$

$$= \frac{4 \times 3850}{60}$$

$$= 256 \text{ hertz}$$

As shown in table 13, the dominant frequency is in the octave band with center frequency of 250 hertz. The solution to reducing noise generated by a planer is in finding a way to prevent the knives from striking the wood.

A study by Stewart and Hart looked at the performance of the spiral cutterhead.[6] With a spiral knife configuration, figure 9, the impact of the knives is transformed into continuous contact with the wood except for narrow strips of wood. The results of Stewart and Hart's investigation indicated a reduction in noise generation from 15 to 25 dB(A). With the conventional straight knife cutterhead, a doubling in the width of the wood increased the sound pressure level by 6 dB(A) or a doubling of the sound pressure level. The spiral cutterhead only increased the sound pressure level by 3 dB(A).[7]

Planer manufacturers should seriously consider including spiral knife cutterheads in any new machine. However, there are several questions a user may have, such as:

a. is it cost effective?

b. is the performance and quality of cut as good?

c. is it difficult to maintain?

It was difficult to establish the cost of a spiral cutterhead planer since no machines are available in the marketplace the size used in school shops. An estimate of the cost of a 24" spiral cutterhead planer, if available, would be about $5000 more than the conventional straight knife thickness planer. Also, the cost of replacement spiral knives would be 2½ to 3 times the cost of straight planer knives.[8] The cost to retrofit an existing machine with a spiral cutterhead is about $300 per inch of knife length or about $7000 for a 24" thickness planer. This study does not recommend retrofitting an existing machine but would seriously consider a new machine when they become available.

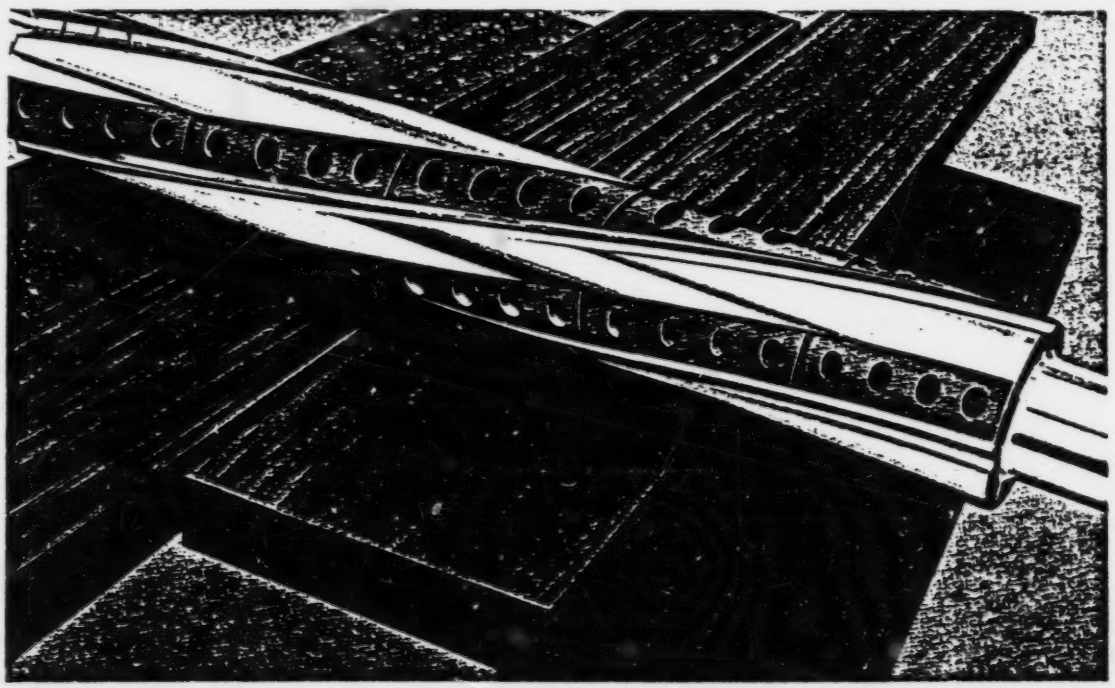


Figure 9 - Spiral Knife Cutterhead

Stewart and Hart's study indicated the cutting performace and the quality of the surface finish was superior with the spiral cutterhead. The straight knife planer sometimes leaves ripples on the surface of the wood. The spiral cutterhead knives contact the wood at an angle resulting in a shearing action. This produces a smoother surface absent of the ripple pattern. Also, the shearing action reduces grain pull-out when planing against the grain of the wood. The wood may not require sanding after it has been past through the thickness planer.

The maintenance of a spiral cutterhead is more difficult and takes longer then the regular straight knives. More care is required to reset the knives to the correct height when being replaced. However, sharpening the knives in the machine is almost as simple as the straight knife machine. A follower travelling in a slot behind the spiral knife keeps the grinding wheel in proper alignment as it moves across the knife. The cutterhead must be disengaged and allowed to float freely, figure 10. Although spiral cutterheads are more difficult to maintain, it should not be a deterrent when considering the purchase of a new machine. Manufacturers of thickness planers have not adopted this new technology for planers of the size used in school woodwork shops. Although it would have been desirable to investigate spiral cutterhead thickness planers, only one machine is in use in British Columbia. It is a new large industrial double spiral cutterhead planer unlike any school machine. It replaced a noisy straight knife planer with very

significant reduction in noise. The Workers' Compensation Board of British Columbia endorses the adoption of the spiral cutterhead. As people demand quieter machines and the governments impose noise abatement regulations, the spiral cutterhead will likely become more available.

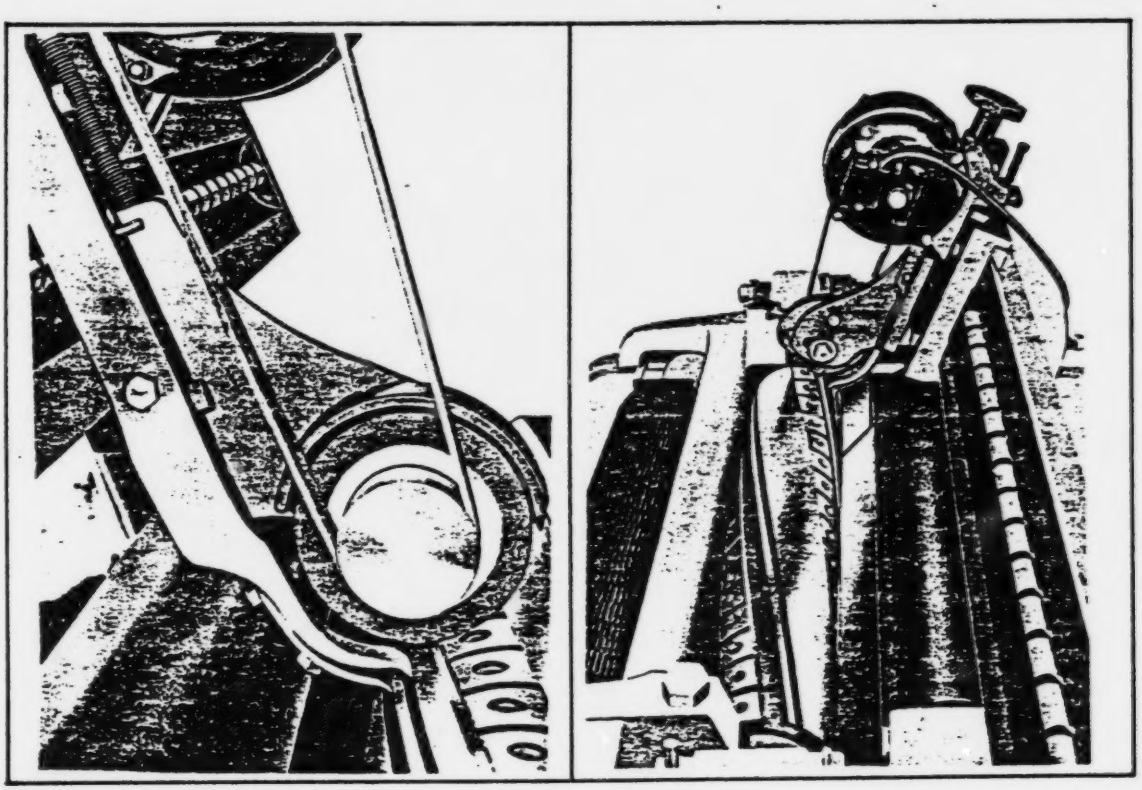


Figure 10 - Sharpening a Spiral Knife Cutterhead

References

1. J.S. Stewart and F.B. Hart, "Analysis and Control of Wood Planer Noise," Sound and Vibration (Ohio: Acoustical Pub. Inc., March 1972) pp. 24-27.

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3. Wayne Ehlert and Gerald Cunico, "Reducing dB Levels on the Wood Planer," School Shop (November 1978), pp. 32-33.

4. Terry Walker and K.T. Feldman, "Low-Cost Acoustical Enclosure for a Wood Planer," Sound and Vibration (Ohio: Acoustical Pub. Inc., November 1973), pp.34-38.

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6. John S. Stewart and D.F. Hart, "Control of Industrial Wood Planer Noise Through Improved Cutterhead Design," Noise Control Engineering (New York: Institute of Noise Control Engineering, July/August 1976), pp.4-9.

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8. Wisconsin Knife Works Catalog and Price List, Beloit, Wisconsin, U.S., 53511.

Chapter V - Saw Blade Noise Control

Saw blades rate second to thickness planers in levels of noise generation. Saw blades operate on table saws and radial arm saws are normally used more frequently and for longer periods of time then the thickness planer in the school shops. They are usually idling at about 80 to 95 dB(A) and cutting at over 100 dB(A). This makes saw blades a major concern for noise reduction.

A. Nature of Saw Blade Noise Generation. Noise generation from circular saw blades can be divided into two catagories: aerodynamic and vibrational.(figure 11)

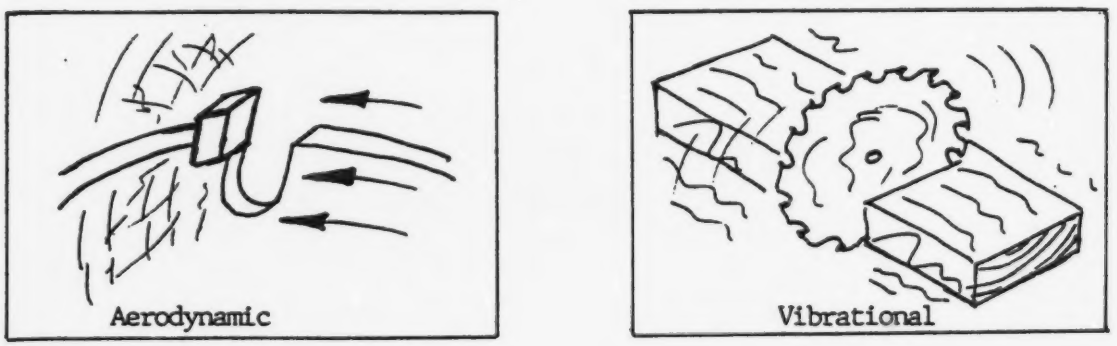
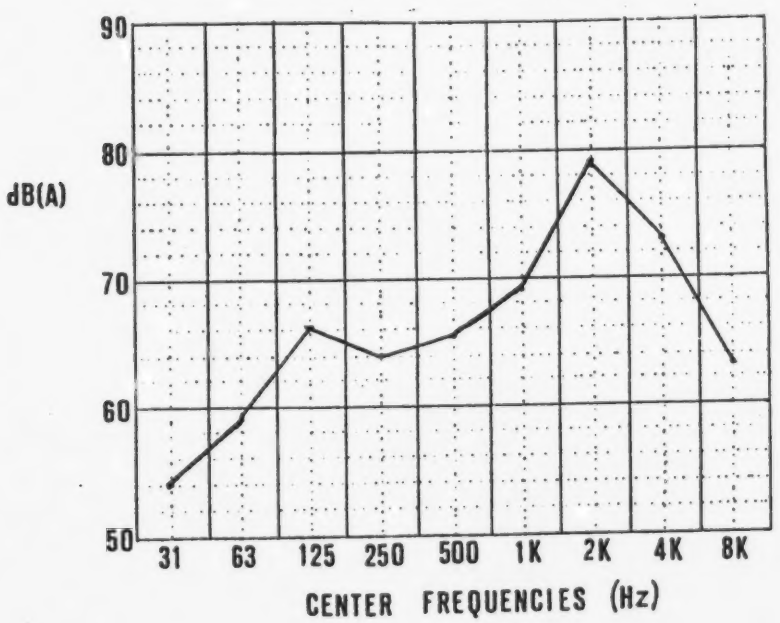


Figure 11 - Types of Saw Blade Noise

1. Aerodynamic Noise. As a saw blade rotates there is air disturbance around the teeth creating noise. Several factors that effect the level of noise generation are: tip speed, gullet depth, and the ratio of the gullet width to the blade thickness.[1] Rake angle and the number of teeth on the saw blade have little effect on noise generation.[2] Noise generation varies as the 5th to 6th

power of the saw blade tip velocity. A doubling of the tip speed increases the noise level by an average of 15 dB(A).[3] Table 14 shows an octave band frequency analysis of a typical 10" circular saw blade when idling.

Table 14 - Octave Band Analysis of Idling
10" Saw Blade - 40 Tooth

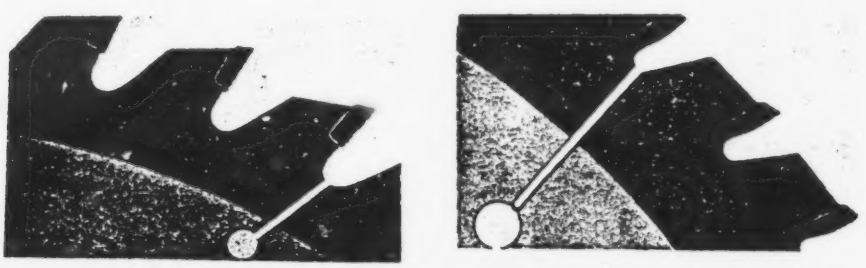


The chart shows the dominant centre frequency at 2000 hertz. This corresponds to the tooth passage frequency. The best way to reduce circular saw blade noise is to reduce the tip speed.

2. Blade Vibration. Aerodynamic forces on the blade or the impact of the teeth on the wood while cutting can cause vibrations in the saw blade which in turn generates noise. When the frequency of the vibrations approaches the resonant frequency of the saw blade it will "scream." A screaming blade can easily be quietened by dampening.

B. Methods of Saw Blade Noise Abatement.

1. Modified Gullet Shape. The gullet shape can be a contributing factor in saw blade noise generation.[4,5] Several companies are now manufacturing saw blades with a smaller modified gullet shape which they claim reduces noise. In this study several of these blades were tested to see if their moderately higher cost, about 10%, were justified. Figure 12 shows the difference between the Nordic NS regular saw blade and the Nordic NSD silent running saw blade.



Nordic NS - regular gullet Nordic NSD - silent running

Figure 12 - Comparison of Regular and Silent Running Gullet Shapes

Table 15 compares the octave band analysis of two 14" Nordic saw blades both with 56 teeth running on a Wadkin radial arm saw. One blade was a regular gullet shape and the other was a modified gullet shape. The difference of 4 dB(A) sound pressure level, although small, is significant. A 5 dB(A) drop was recorded when crosscutting a test piece of 2" x 8" oak. A similar test was made on two 12" saw blades running on a Wadkin table saw, table 16. Again one blade had the regular gullet and the other blade had the modified gullets. There was no difference in sound

Table 15 - Comparison of Regular Gullet and Modified Gullet - 14" Saw Blade

Octave Band Frequency Analysis

MACHINE - Wadkin 14" radial arm saw (3400 r.p.m.)

TEST EQUIPMENT - QUEST #215-45 S.P.L. METER AND OCTAVE BAND ANALYZER

TEST #1 - Nordic NS - 14" x 56T regular gullet saw blade, meter positioned in front near operators ear, guard in place, idling.

TEST #2 - Nordic NSD - 14" x 56T silent running saw blade, same as above.

TEST #3 -

dB(A)

TEST	#1	#2	#3
dB(A)	94	90	
dB LIN.	93	89	
31 Hz.	62	63	
63 Hz.	76	79	
125 Hz.	63	65	
250 Hz.	65	66	
500 Hz.	71	70	
1K Hz.	70	70	
2K Hz.	86	84	
4K Hz.	93	88	
8K Hz.	73	72	

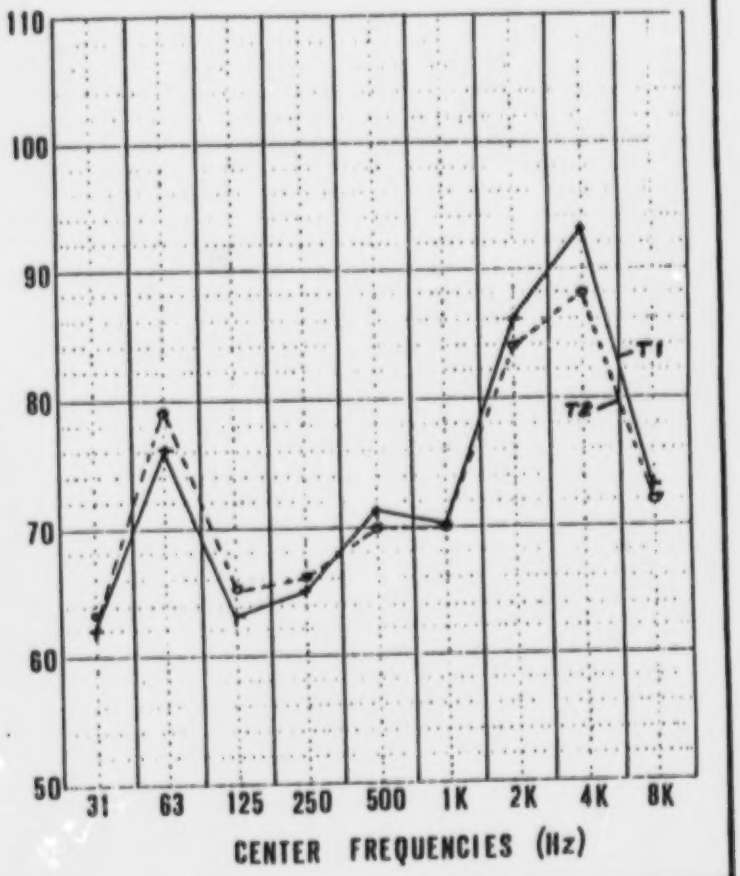


Table 16 - Comparison of Regular Gullet and Modified Gullet - 12" Saw Blades

Octave Band Frequency Analysis

MACHINE - Wadkin table saw (3600 r.p.m.)

TEST EQUIPMENT - QUEST 215-45 S.P.L. METER AND OCTAVE BAND ANALYZER

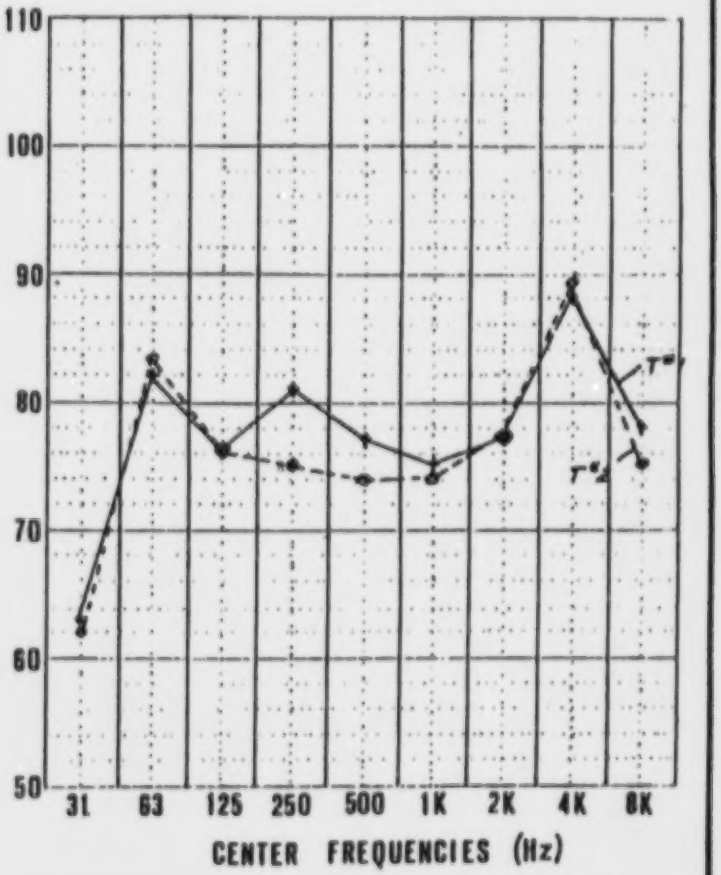
TEST #1 - Nordic NR - 12" x 48T regular gullet saw blade, meter positioned in front near operators ear, no guard, blade 4" above table.

TEST #2 - Nordic NSD - 12" x 48T silent running blade, same as above.

TEST #3 -

dB(A)

TEST	#1	#2	#3
dB(A)	91	91	
dB LIN.	90	90	
31 Hz.	63	62	
63 Hz.	82	83	
125 Hz.	76	76	
250 Hz.	81	75	
500 Hz.	77	74	
1K Hz.	75	74	
2K Hz.	77	77	
4K Hz.	88	89	
8K Hz.	78	75	



pressure level, although, there was a 3 to 5 dB(A) drop in the 250 to 500 hertz range. Several other tests were tried on 10" saw blades with little or no drop in sound pressure levels. Both the regular gullet and the modified gullet blades produced good cuts in the wood and cleared the shavings well.

Modifying saw blade gullets is a new technology that several manufacturers are employing. From the findings of this study it appears little is gained in modifying gullets in the smaller 10" saw blades. However, in the larger 14" saw blades it is worthwhile considering.

2. Dampening Layer. Blade dampening material consists of a viscoelastic adhesive layer covered with an aluminum foil or a thin steel ring fastened to the surface of the blade. It can be fastened to both sides of the blade or usually to one side. As the blade and dampening layer bend under the influence of resonant vibration, a shear force is applied to the viscoelastic material causing deformation. This converts the mechanical energy of vibration into negligible heat rather than acoustical noise. Although blade dampening has no effect on reducing aerodynamic noise, a reduction of about 3 dB(A) can be anticipated.[6,7] Significant noise reduction can be obtained with dampening when a "screaming" blade dominates the noise generated. Figure 13 shows the results of dampening on a screaming blade in a study done by Niemiec in 1976. A dramatic reduction was obtained in the very irritating 4000 hertz level. For "screaming" blades, the application of dampening eliminates the screaming effect.

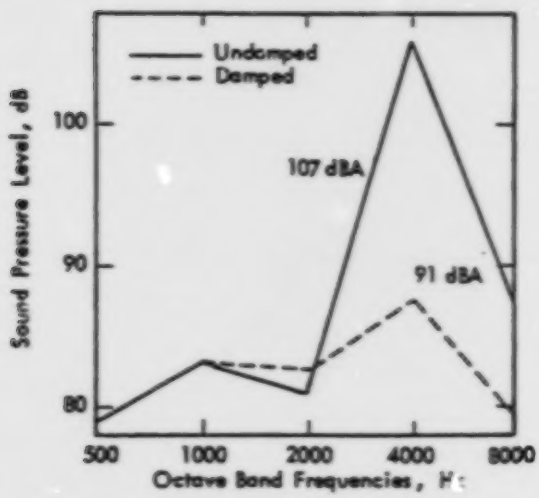


Figure 13 - Effects of Dampening on Screaming Saw Blade

This study tried a 3M product called "Scotchdamp #SJ2012", a saw blade damper. The damper consisted of a 10 mil thick steel ring with a 2 mil thick viscoelastic damping ploymer adhesive. The 9" ring was fastened to the arbor nut side of the 12" radial arm saw blade. Great care was taken to clean the blade so there would be 100% adhesion. No reduction in noise was obtained with the blade idling but a 3 - 4 dB(A) reduction was obtained when crosscutting a 2" x 8" test piece of oak.

The life expectancy of the dampening ring is 2 or 3 sharpening cycles before replacement. However, more frequent replacement may be required if the blade is over-heated or abused. The cost of the dampening ring is approximately $15. This appears to be expensive for the little gain in noise abatement; therefore, this study would recommend blade dampening, only if the noise were

caused by a screaming blade.

3. Large Stiffening Collars. Another method which can be used to reduce saw blade vibration is large stiffening collars, either by themselves or in conjuction with viscoelastic dampening layer, figure 14.[8]

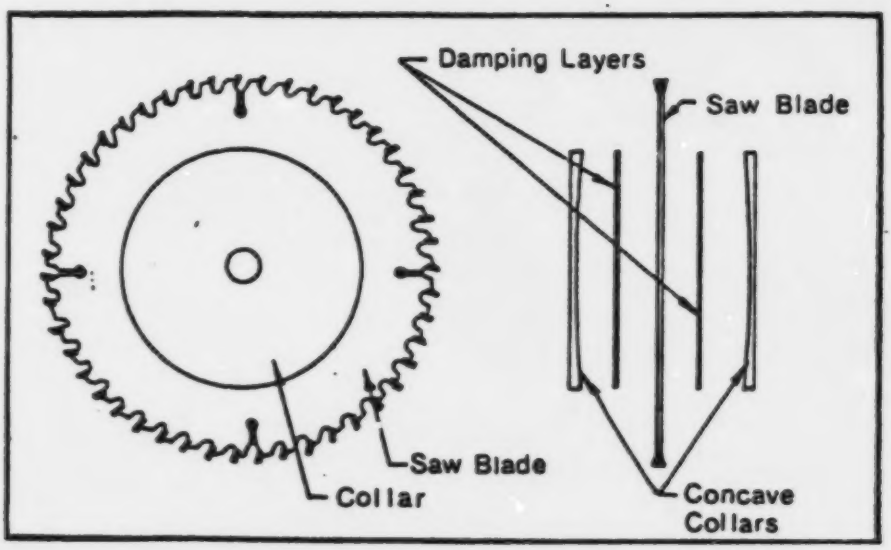


Figure 14 - Large Stiffening Collars and Dampening Layer

However, in order for stiffening collars to be effective as a damping treatment they must cover appreciably greater than half the diameter of the blade, figure 15.[9] This severely limits the depth of cut if adequate sound reduction is to be obtained. A typical 10" table saw comes from the manufacturer with small stiffening collars from 2" to 3" in diameter. Since most of the stock in school woodwork shops is 2" or less in thickness, 5" stiffening collars on a 10" saw blade would not hinder operations very much yet would help in noise abatement. A side benefit of larger stiffening collars is the extra rim support resulting in

a smoother cut. Research supports the use of larger stiffening collars on both the table saw and the radial arm saw. The noise abatement that can be expected would range from 0 to 3 dB(A) for idling saw blades and 3 to 5 dB(A) when cutting.

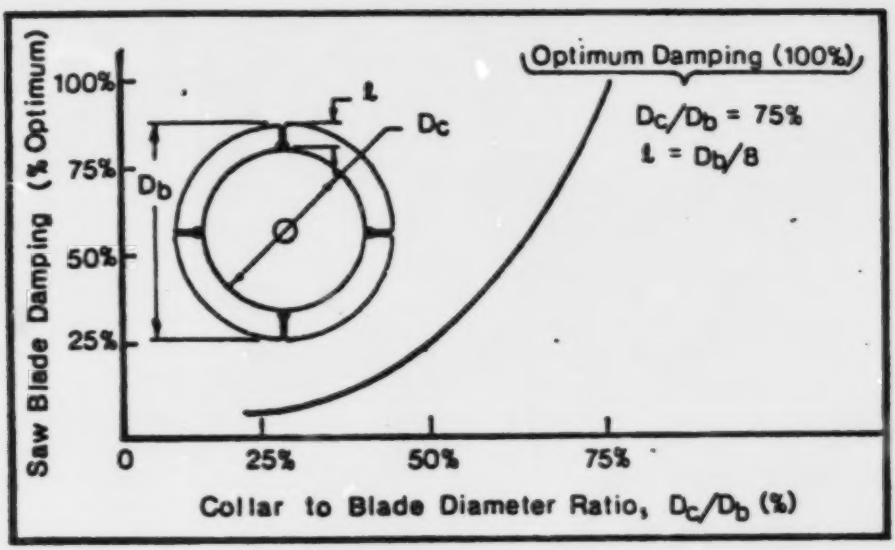


Figure 15 - Effect of Damping Collar Diameter on Blade Damping

4. Lower R.P.M. The tip speed was found to be the single most important parameter causing an increase in the sound pressure levelat the operator's position of around 15 dB(A) for each doubling of tip speed.[10] The recommended tip speed is about 200 feet/second.[11] Table 17 gives the recommended operating r.p.m. for saw blade sizes found in school woodwork shops. All table saws and most radial arm saws investigated were below the recommended r.p.m. The only exception was the 14" Wadkin radial arm saw where the speed was about 200 r.p.m. above the recommended speed. Since the 14" radial arm saw blade is mounted directly

on the electric motor shaft, it would not be practical to modify the speed.

Although the saw blade tip speed is a large factor in noise generation, results of this study do not recommend changing saw blade r.p.m. Most saw blades now operate within the recommended r.p.m. limits.

Table 17 - Recommended R.P.M. for Saw Blades (200'/sec)

Blade Size	Recommended Operating R.P.M.
8"	5730
10"	4580
12"	3820
14"	3275

5 Blade Enclosure. A study done by Zockel, Bies, and Page at the University of Adelaide, Australia, investigated the noise abatement of a guard around a radial arm saw blade.[12] Figure 16 shows the configuration of the noise guard.

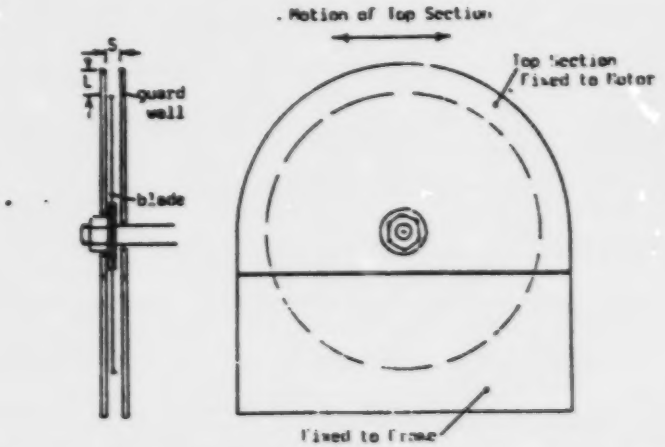


Figure 16 - Noise Guard on a Radial Arm Saw

The critical parameters of the noise guard that the spacing between the hard walls of the guard should be as small as possible and the blade peripheries should be greater than three times the spacing, that is L = 3 x S. All air entry points through the sides of the guard should be sealed. Table 18 shows the data obtained using a 16" diameter saw blade operating at 3000 r.p.m.[13] Over 10 dB(A) reduction was obtained when idling and 3 to 4 dB(A) while cutting.

Table 18 - Noise Levels for Noise Guard (7 mm spacing)

		SPL at 1 meter, 45 from blade - dB(A)
1.	motor noise	66
2.	standard guard	90
3.	noise guard with 1 mm gaps around shaft and between top and bottom sections, circumference open	82
4.	as 3. with gap around shaft sealed	79
5.	as 4. with gap between top and bottom sections sealed	76
6.	as 4. with circumference of top section sealed	76.5

Additionally it has been found experimentally that a saw blade rotating between two narrowly spaced guard walls is a remarkably effective pump which very efficiently scavanges saw dust and expells it with great force in a stream to the rear of the cut. This feature alone would recommend the design even if it were not a successful suppressor of noise.[14]

The results of the Zokel,Bies, and Page study appears to be encouraging for noise abatement of a radial arm saw.

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9. Ibid.

10. Zockel, Bies, and Page, "Noise Reduction on Saws," p. 374.

11. J.S. Stewart, "A Design Guide For Circular Saw Noise Control," contract report for the Southern Furniture Manufacturers Association," Feb. 1978, pp. 37-38.

12. Zockel, Bies, and Page, "Noise Reduction on Saws," pp. 373-383.

13. Ibid.

14. Bies, "Saw Blade Idling Noise .," p. 316.

Chapter VI - Jointer Noise Control

Jointers are not as large a concern for noise generation as thickness planers, radial arm saws, or table saws. In the shop the jointer is not used as much as the noisier machines. However, jointers can generate noise levels over 90 dB(A), (table 3, page 11) which can cause damage to hearing.

A Nature of Jointer Noise Generation. The sources of jointer noise generation is similar to thickness planer: aerodynamic and vibrational noise. Figure 17 shows a typical crossection of a jointer. The rotating cutterhead in close proximity to the front and back tables creates the typical siren effect associated with a jointer. Like the thickness planer, the noise generated is proportional to the 4th power of the cutterhead tip velocity. When cutting a piece of wood the impacting of the knives on the wood set up vibrational forces both in the wood and the machine which are radiated as acoustical energy.

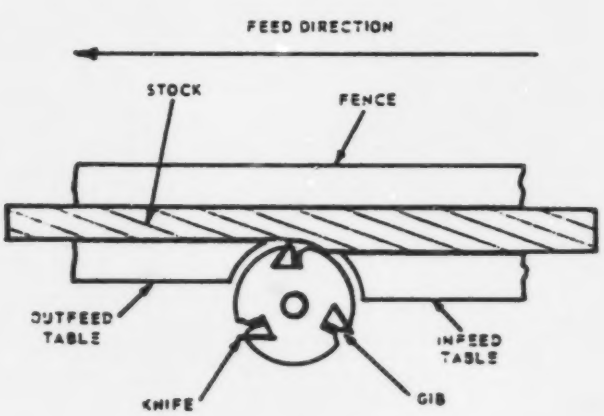


Figure 17 - Typical Jointer Crossection

B. Methods of Jointer Noise Abatement. This study investigated two methods of noise abatement: reduced cutterhead r.p.m. and modified table edge near the cutterhead.

1. Reduced R.P.M. Both idle noise and cutting noise levels were taken on a 12" Invincible jointer before the speed was modified. The starting speed was 5600 r.p.m. The pulley on the motor was changed and the cutterhead speed was reduced to 4000 r.p.m. Table 19 shows the results. A drop of 7 dB(A) in idle noise level and a drop of 6 dB(A) in cutting noise level were recorded. The same test piece of 2" x 8" oak was used before and after speed change. Lowering the cutterhead speed on a jointer is an easy way to obtain a significant noise reduction.

2. Slotted Table Edge. On the 12" Invincible jointer the edges of the table close to the cutterhead are slotted. It was surmised the manufacturer did this to help cut noise generation. This study tried the same treatment on a 6" Beaver jointer to see if any noise abatement took place, figure 18.

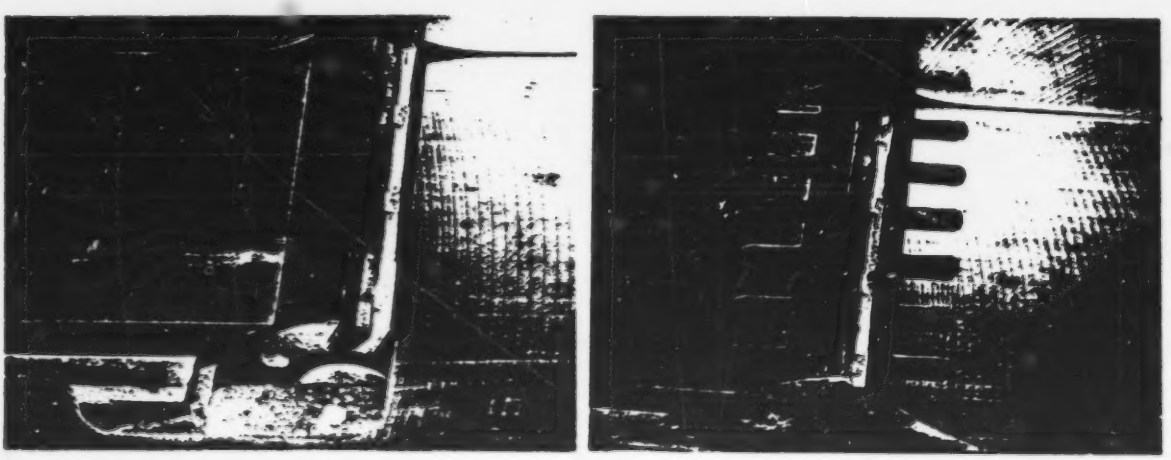


Figure 18 - Beaver Jointer Before and After Slotting

Table 19 - Effect of Reduced R.P.M. on Noise Generation - 12" Invincible Jointer

Octave Band Frequency Analysis

MACHINE - 12" Invincible Jointer

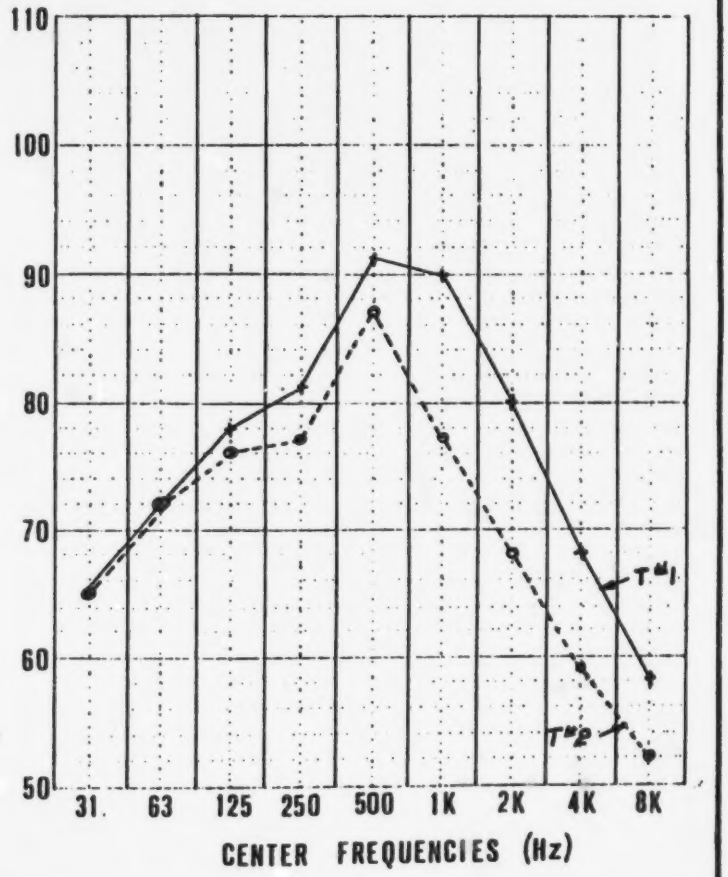
TEST EQUIPMENT - QUEST #215-45 S.P.L. METER AND OCTAVE BAND ANALYZER

TEST #1 - 5600 r.p.m., idle noise, exhaust system on, meter positioned near operators ear level.

TEST #2 - Same as test #1. but 4000 r.p.m.

TEST #3 -

TEST	#1	#2	#3
dB(A)	91	84	
dB LIN.	93	87	
31 Hz.	65	65	
63 Hz.	72	72	
125 Hz.	78	76	
250 Hz.	81	77	
500 Hz.	91	87	
1K Hz.	90	77	
2K Hz.	80	68	
4K Hz.	68	59	
8K Hz.	58	52	



A 2 dB(A) drop in noise level was obtained both in idle and cutting mode. From the results of this one test it appears not to be worthwhile. However, slotting the table on a larger 9" or 12" jointer may yield better results.

Table 20 - Comparison of 6" Beaver Jointer Noise Level Before and After Slotting Table

Octave Band Frequency Analysis

MACHINE - 6" Beaver Jointer

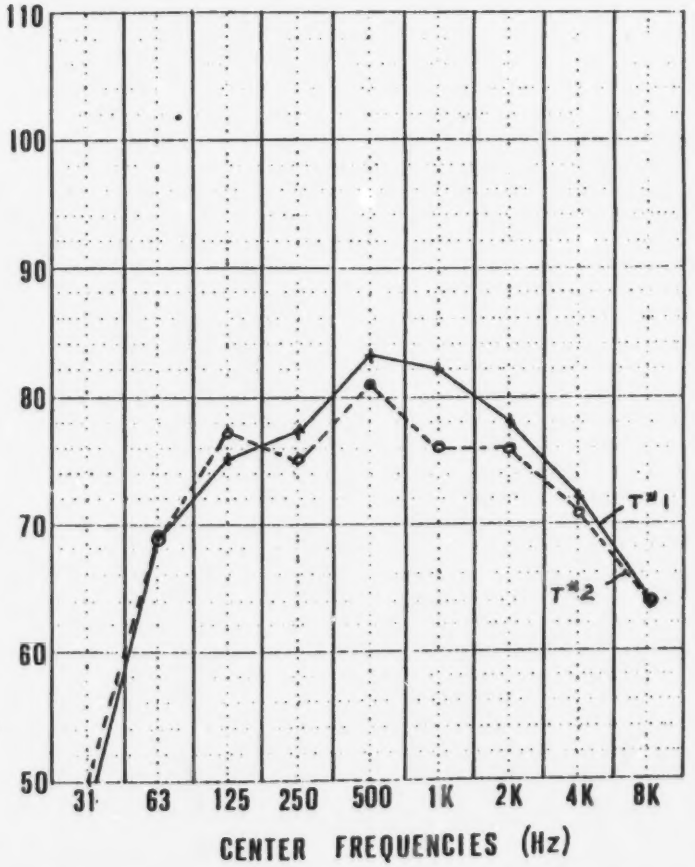
TEST EQUIPMENT - QUEST #215-45 S.P.L. METER AND OCTAVE BAND ANALYZER

TEST #1 - Jointer before modification, 5900 r.p.m., meter positioned near operators ear level.

TEST #2 - Same as test #1 but the table slotted.

TEST #3 -

TEST	#1	#2	#3
dB(A)	84	82	
dB LIN.	87	84	
31 Hz.	46	47	
63 Hz.	69	69	
125 Hz.	75	77	
250 Hz.	77	75	
500 Hz.	83	81	
1K Hz.	82	76	
2K Hz.	78	76	
4K Hz.	72	71	
8K Hz.	64	64	

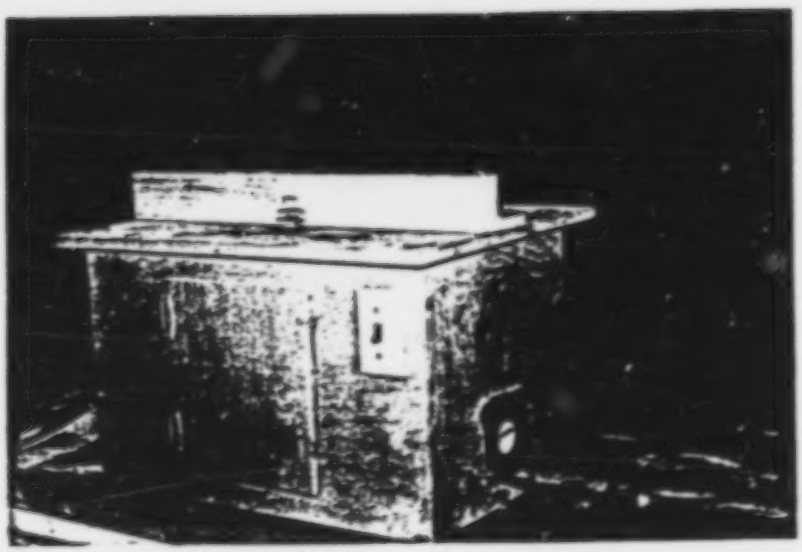


Chapter VII - Router Noise Control

The hand electric router is one of the noisiest portable electric tools as well as one of the most irritating. The electric router operates between 20 000 and 25 000 r.p.m., omitting a high frequency noise that is very irritating. The average sound pressure level for idling is 95 dB(A) and 99 dB(A) when cutting (see table 3, page 11). With these high noise levels and with the high amount of use the routers get in school woodwork shops, there is a need to investigate methods of noise abatement. This study looked at an enclosure to surround the router.

Router Enclosure. Figure 19 and 20 give details on the construction of the enclosure. The router mounted on a table is a very common application used in the shop. The enclosure was lined with lead sheet and 1" acoustical fibreglass the same as used in the thickness planer enclosure.

Several modifications were required before a good working unit was acceptable. On the initial enclosure the movement of air for cooling came only from the router motor. This proved not to be sufficient since the motor became too hot after only ten minutes of operation. A small 120 volt fan was added to help pull air through the enclosure. This did not work as well as expected. On closer investigation the internal baffles allowed the forced air movement to cross the bottom of the enclosure bypassing the motor. A further modification placed the internal baffles to allow the air to flow from the bottom to top passing by the motor. This proved to work satisfactorily.



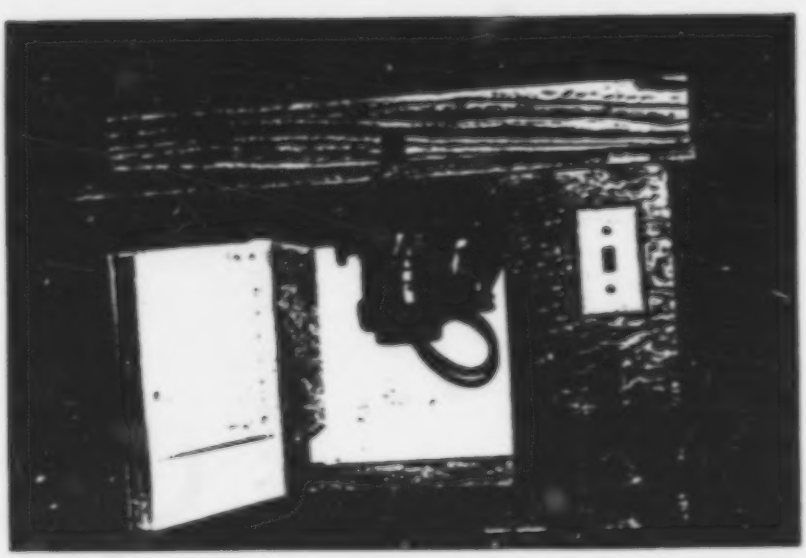


Figure 19 - Router Table Enclosure

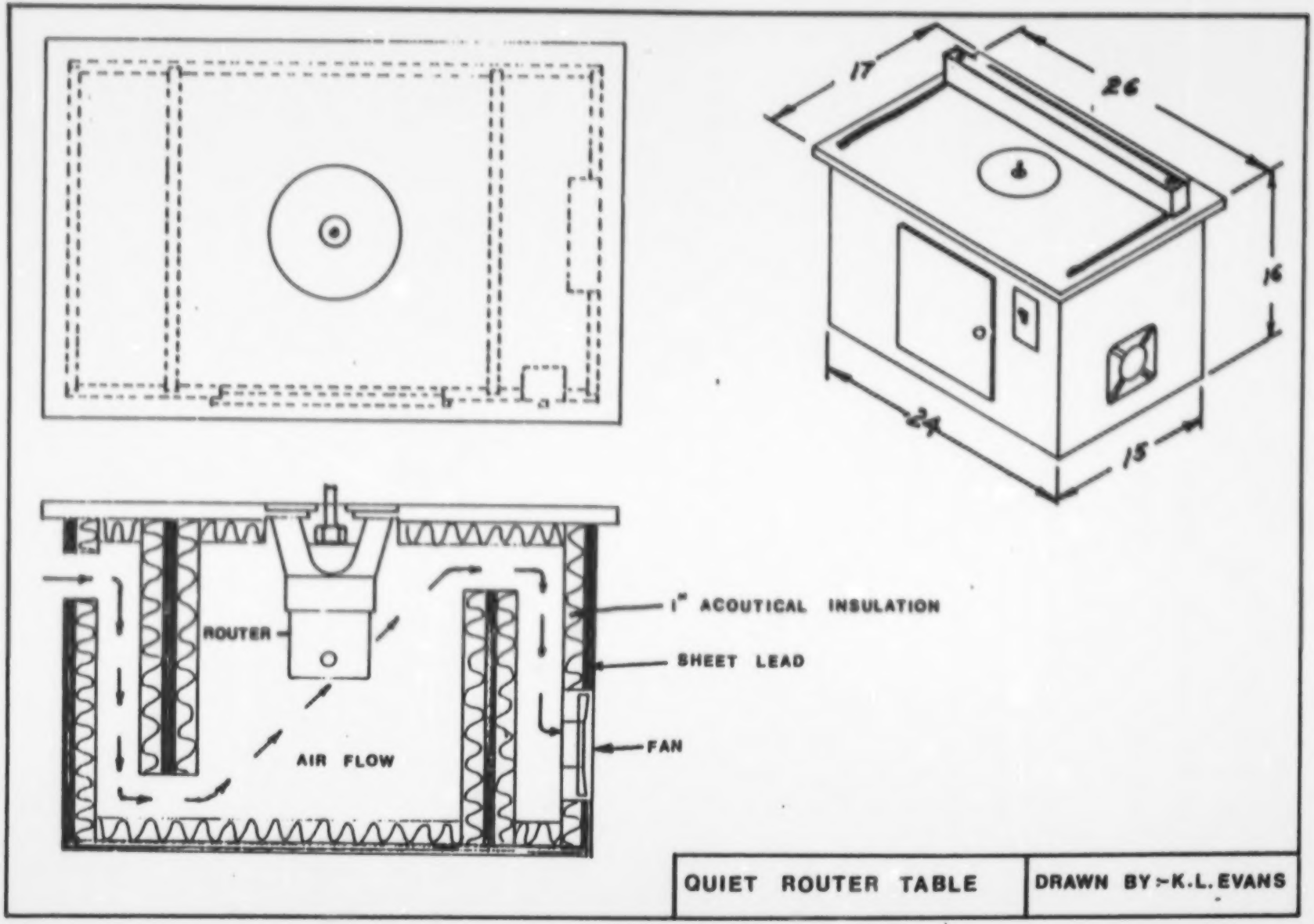


Figure 20 - Router Table Enclosure Details

The sheet lead and acoustical fibreglass was contact cemented in place. To make the unit easier to use an electric plug was mounted inside the enclosure to plug in the router and fan. The power cord was wired to a switch on the outside of the enclosure to make the router easier and safer to use. Weather stripping was added to the access door to prevent noise from radiating out around the edges. The enclosure worked very well. Table 21 shows a reduction of 6 dB(A) in idle speed noise and a 12 dB(A) drop in the 250 octave band frequency which is the irritating frequency.

Table 21 - Comparison of Router Noise with and Without Enclosure

Octave Band Frequency Analysis

MACHINE - Rockwell 150m

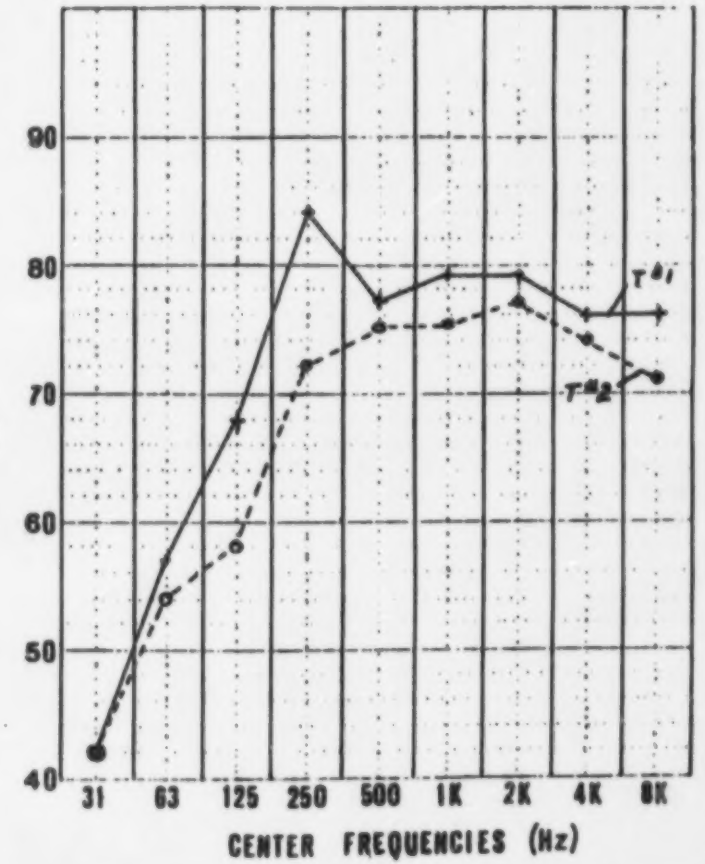
TEST EQUIPMENT - QUEST #215-45 S.P.L. METER AND OCTAVE BAND ANALYZER

TEST #1 - Router without enclosure, idling, Meter positioned in front at ear level.

TEST #2 - As test #1 but with router in enclosure

TEST #3 -

TEST	#1	#2	#3
dB(A)	87	81	
dB LIN.	87	80	
31 Hz.	42	42	
63 Hz.	57	54	
125 Hz.	68	58	
250 Hz.	84	72	
500 Hz.	77	75	
1K Hz.	79	75	
2K Hz.	79	77	
4K Hz.	76	74	
8K Hz.	76	71	



Chapter VIII - Conclusions and Recommendations

Secondary woodwork shops are noisy places to work and can be potentially damaging to hearing. There are many ways to either cut down the noise at the source or to put an enclosure in the path of the noise. There will be situations where ear protection will be desired; however, this study has investigated machinery noise abatment and the following methods are recommended:

A Thickness Planers

1. Keep cutterhead knives sharp.
2. Reduce cutterhead r.p.m.
3. Use dampening material inside cover of machine.
4. Build an enclosure to surround the machine.
5. Keep bearings lubricated and belts aligned and tensioned.
6. If purchasing a new machine consider segmented or spiral cutterhead planers.

B. Saw Blades

1. Use the largest collar size that can be accommodated.
2. Use a viscoelastic dampening ring for screaming blades.
3. Replace saw blades with smaller modified gullet blades.
4. Build an enclosure for radial arm saw blade.

C. Jointers

1. Reduce cutterhead r.p.m.

D. Electric Routers

1. Build an enclosure around the router.

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